How we reduced logs costs by moving from Elasticsearch to Grafana Loki

Igor Latkin

++ High Load Armenia

Co-organizer

Yandex

WHO AM I?

IGOR LATKIN

Co-founder & System Architect @ KTS

- Corporate systems
- Non-standard projects
- Mobile
- DevOps

AGENDA

AGENDA

1. Log collection task
2. Loki architecture
3. Our journey of logs transferring from ES to Loki
4. (bonus) Loki configuration tips & tricks

WHAT THIS TALK IS NOT

- Loki or Elasticsearch tutorial
- Loki vs Elasticsearch comprehensive comparison
- Complete set of instructions how to transfer logs in your environment

LOG COLLECTION PROBLEM

How to collect

How to store

How to extract metadata

How to query

MULTIPLE SOURCES

KUBERNETES CLUSTER

VIRTUAL MACHINES

CLOUD ENVS

WINDOWS EVENTS

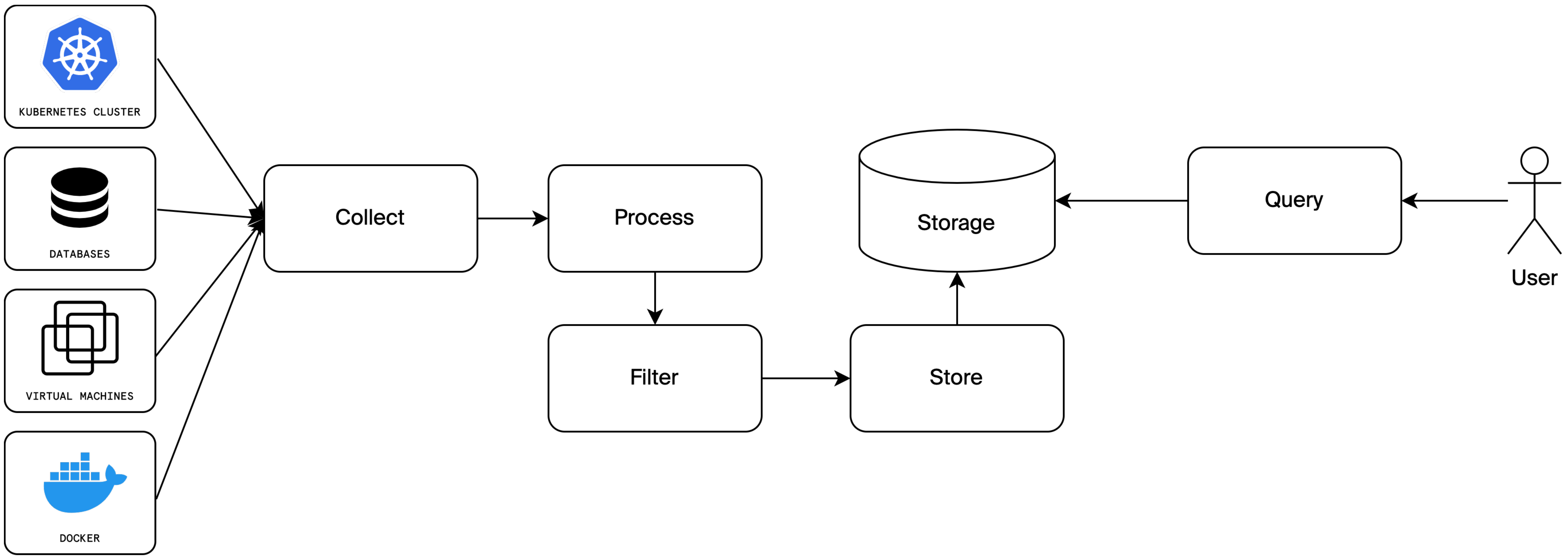
DATABASES

TRAFFIC SNIFFING

SYSLOG

DOCKER

LOGGING PIPELINE



WE ALL KNOW THEM

High Load Armenia

rsyslog

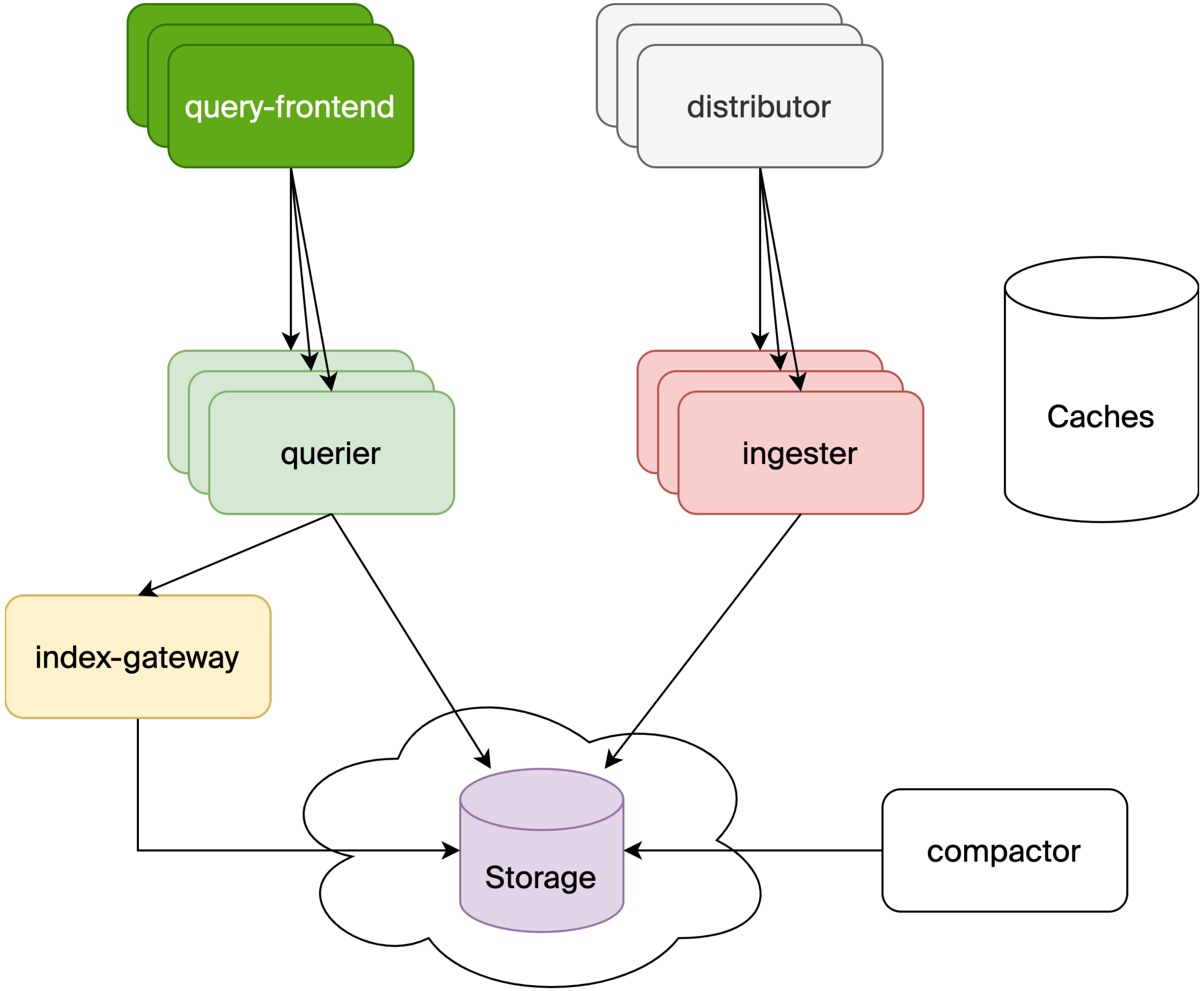
elastic

graylog

Grafana loki

ClickHouse

→ LOKI ARCHITECTURE


query-frontend
distributor
querier
ingester
Caches
index-gateway
Storage
compactor

INDEXING

```
2019-12-11T10:01:02.123456789Z {app="nginx",cluster="us-west1"} GET /about
```

Timestamp
with nanosecond precision

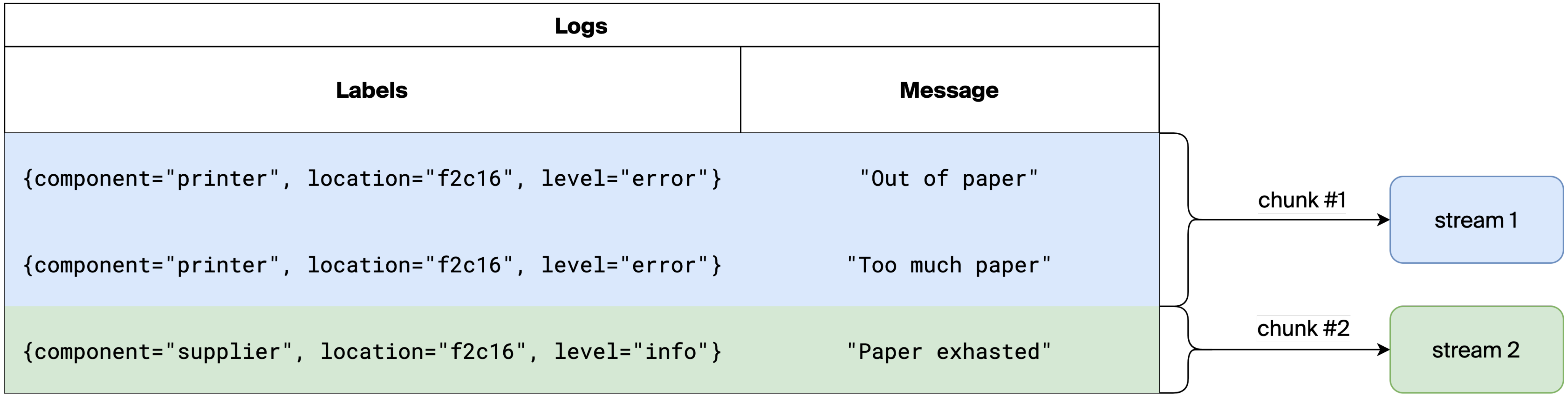
Prometheus-style Labels
key-value pairs

Content
logline

indexed

unindexed

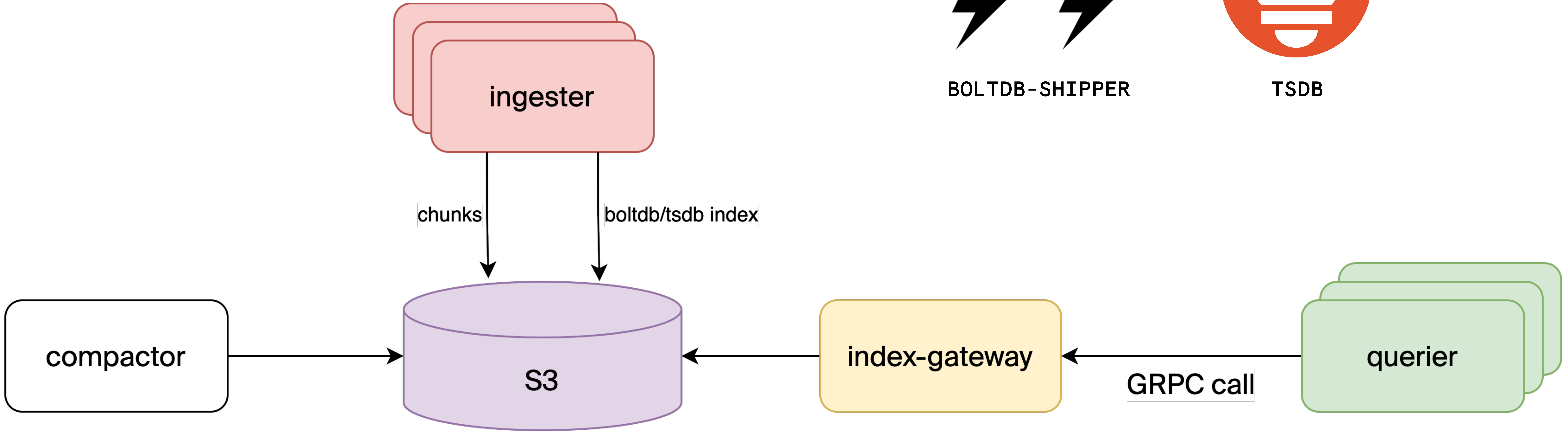
STREAMS



Logs	
Labels	**Message**
{component="printer", location="f2c16", level="error"}	"Out of paper"
{component="printer", location="f2c16", level="error"}	"Too much paper"
{component="supplier", location="f2c16", level="info"}	"Paper exhasted"

CHUNKS & INDEX

CHUNKS & INDEX → S3

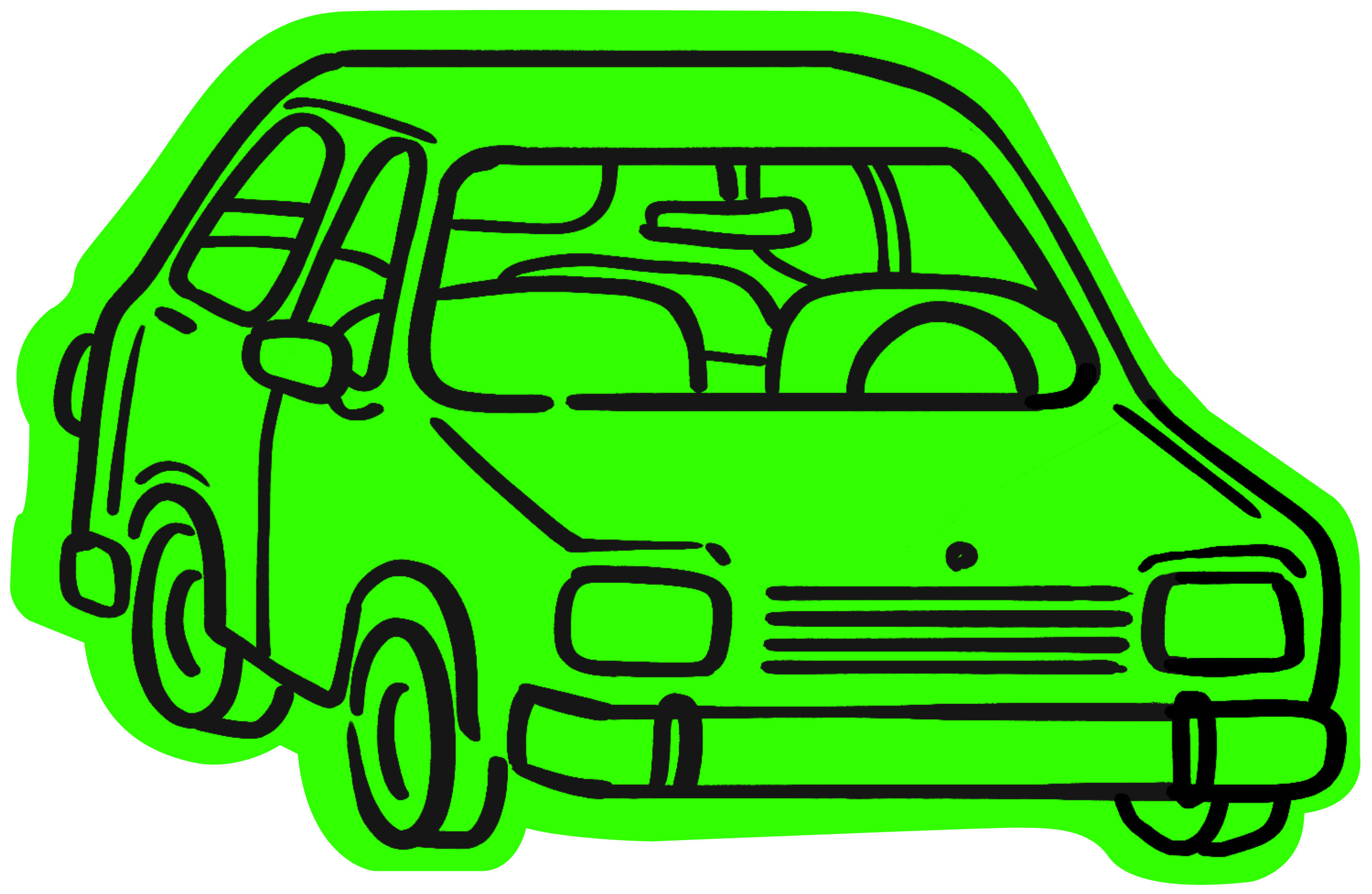


BOLTDB-SHIPPER

TSDB

→ ELASTICSEARCH → LOKI

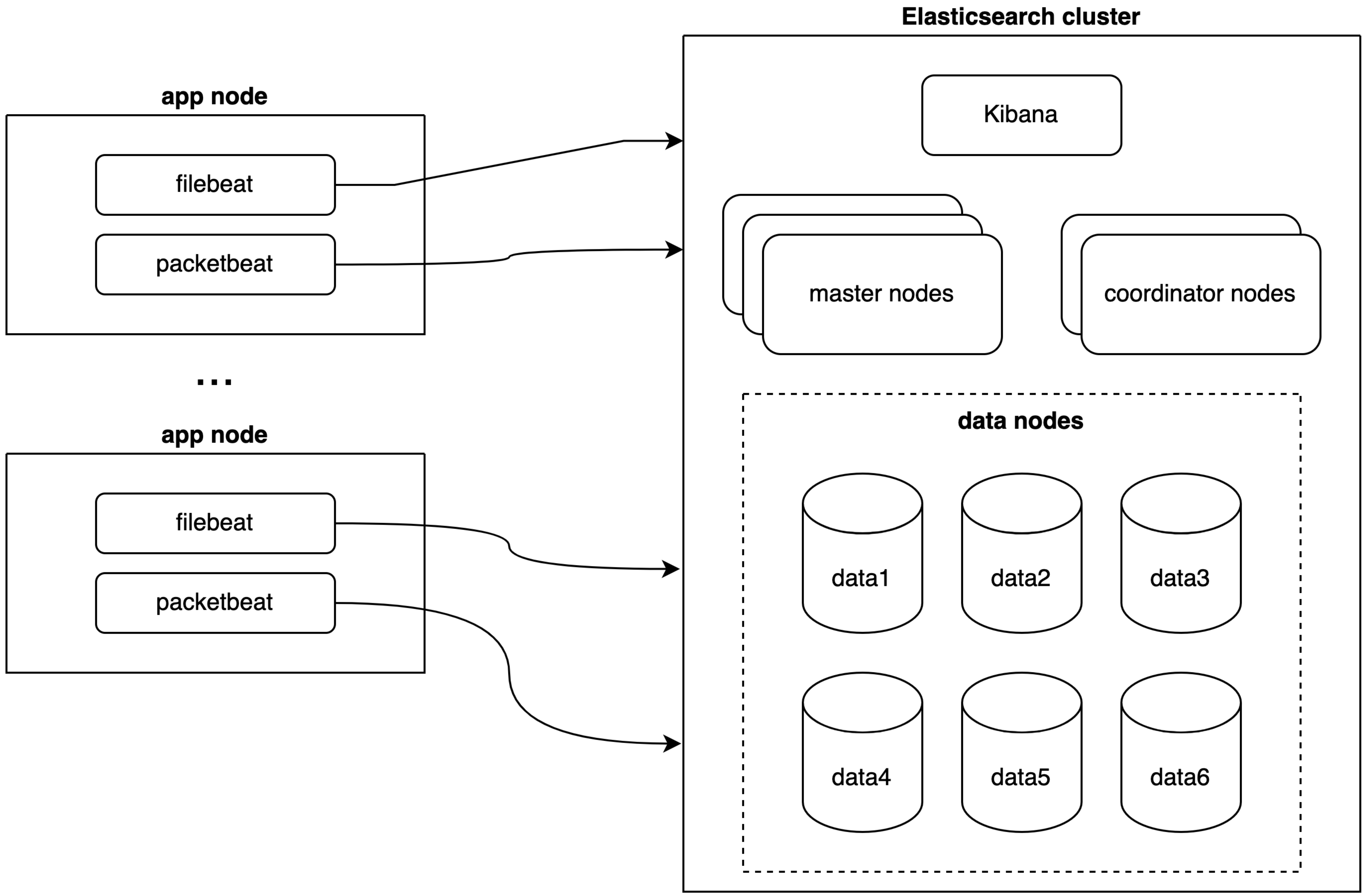
WHY WE DECIDED TO MOVE?



MOTIVATION TO DITCH ELASTIC

1. Huge money burden
2. Hard maintainability

ELASTICSEARCH-BASED INFRA



MIGRATION PLAN

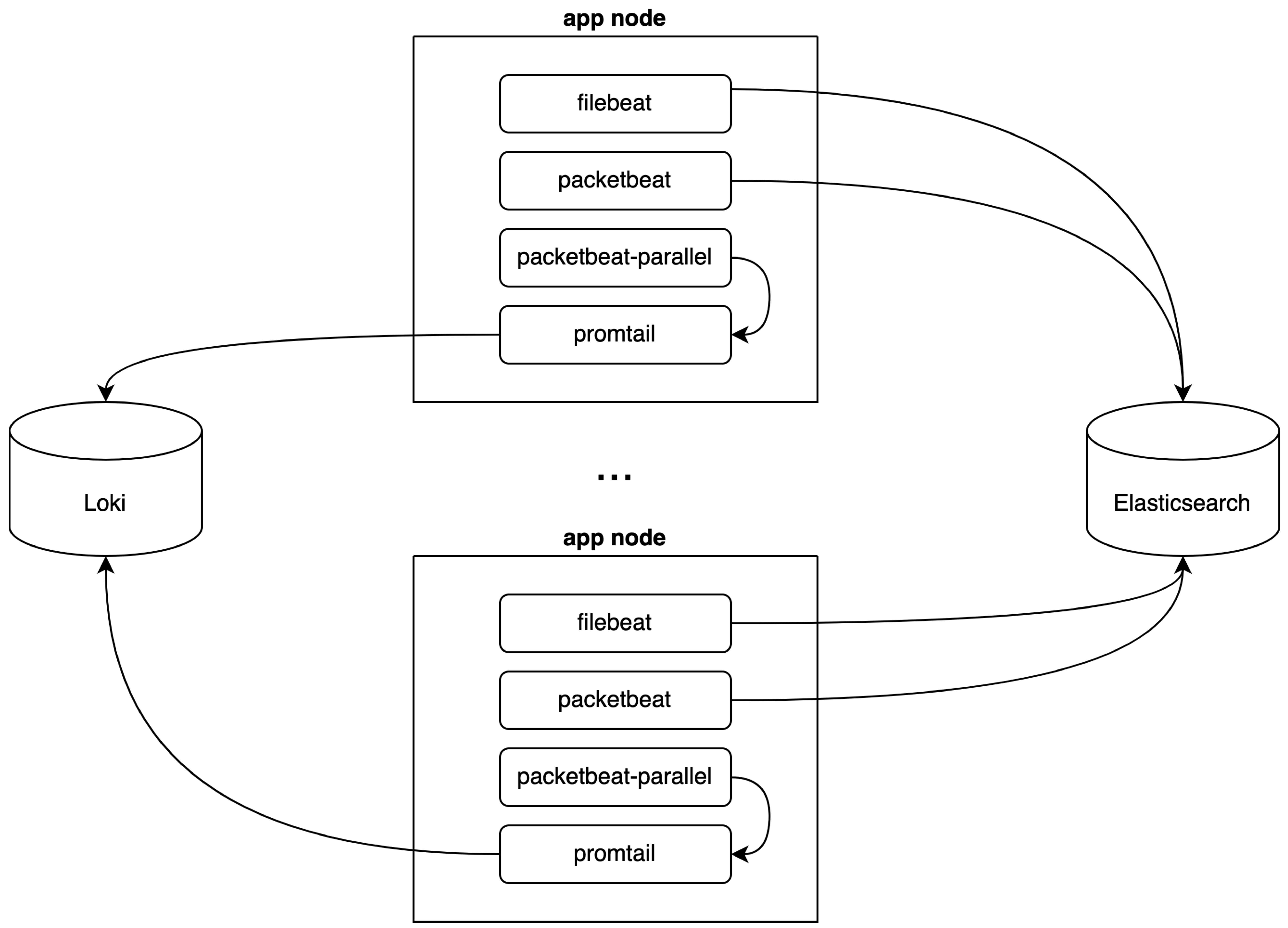
1. Deploy Loki cluster into Kubernetes
2. Deploy S3 storage
3. Start collecting live logs in Loki
4. Solve troubles, constantly reconfigure Loki to handle the load
5. Transfer old logs
6. Fail multiple times
7. Succeed, wait for the transfer to complete
8. Demolish Elasticsearch cluster

MIGRATION PLAN

1. Deploy Loki cluster into Kubernetes
2. Start collecting live logs in Loki
3. Transfer old logs

COLLECTING LIVE LOGS IN LOKI

NOT BREAKING EVERYTHING

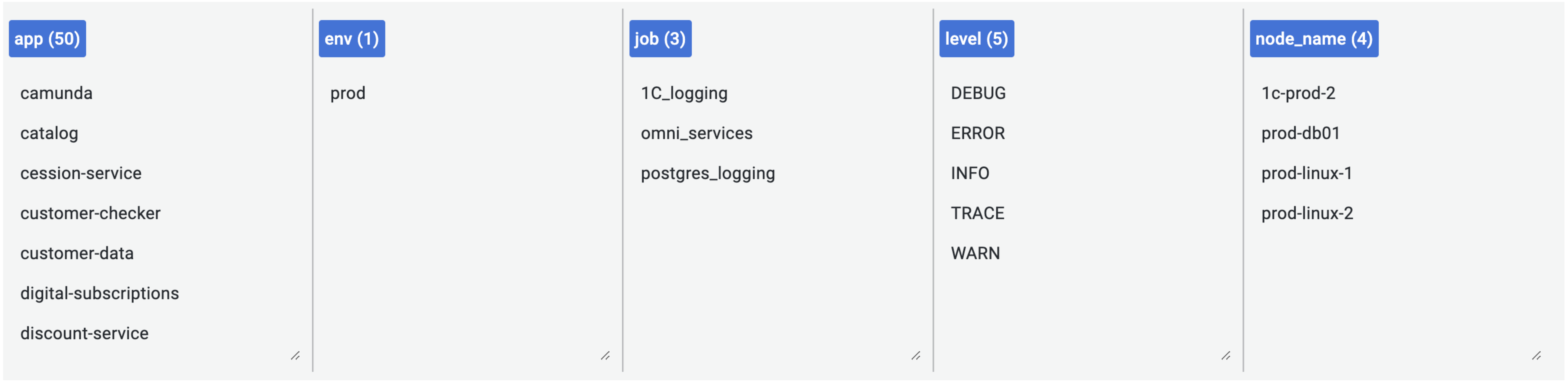


COLLECTING LOGS FROM FILES

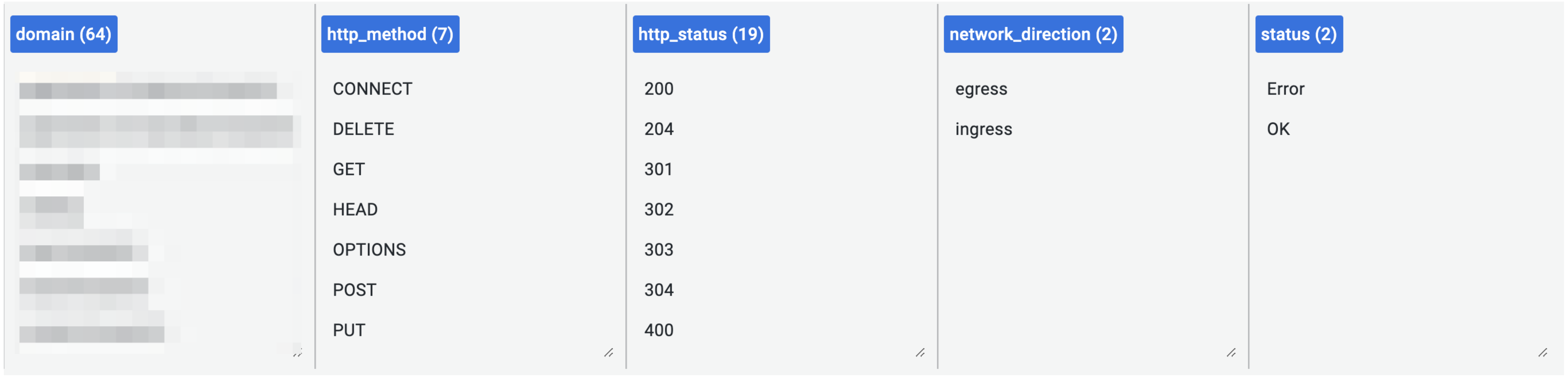
- Application logs
- Packetbeat logs
- Postgres logs (new)
- 1C logs

```yaml
scrape_configs:
- job_name: system
  static_configs:

  - targets:
        - localhost
    labels:
      job: omni_services
      __path__: /var/log/omni/services/*/*log

  - targets:
        - localhost
    labels:
      job: packetbeat
      __path__: {{ promtail_packetbeat_folder }}/output

  - targets:
        - localhost
    labels:
      job: postgres_logging
      __path__: {{ promtail_postgres_folder }}/*/log/*log
```

EXTRACTED LABELS



app (50)	env (1)	job (3)	level (5)	node_name (4)
camunda	prod	1C_logging	DEBUG	1c-prod-2
catalog		omni_services	ERROR	prod-db01
cession-service		postgres_logging	INFO	prod-linux-1
customer-checker			TRACE	prod-linux-2
customer-data			WARN	
digital-subscriptions				
discount-service				



domain (64)	http_method (7)	http_status (19)	network_direction (2)	status (2)
[redacted]	CONNECT	200	egress	Error
	DELETE	204	ingress	OK
	GET	301		
	HEAD	302		
	OPTIONS	303		
	POST	304		
	PUT	400		

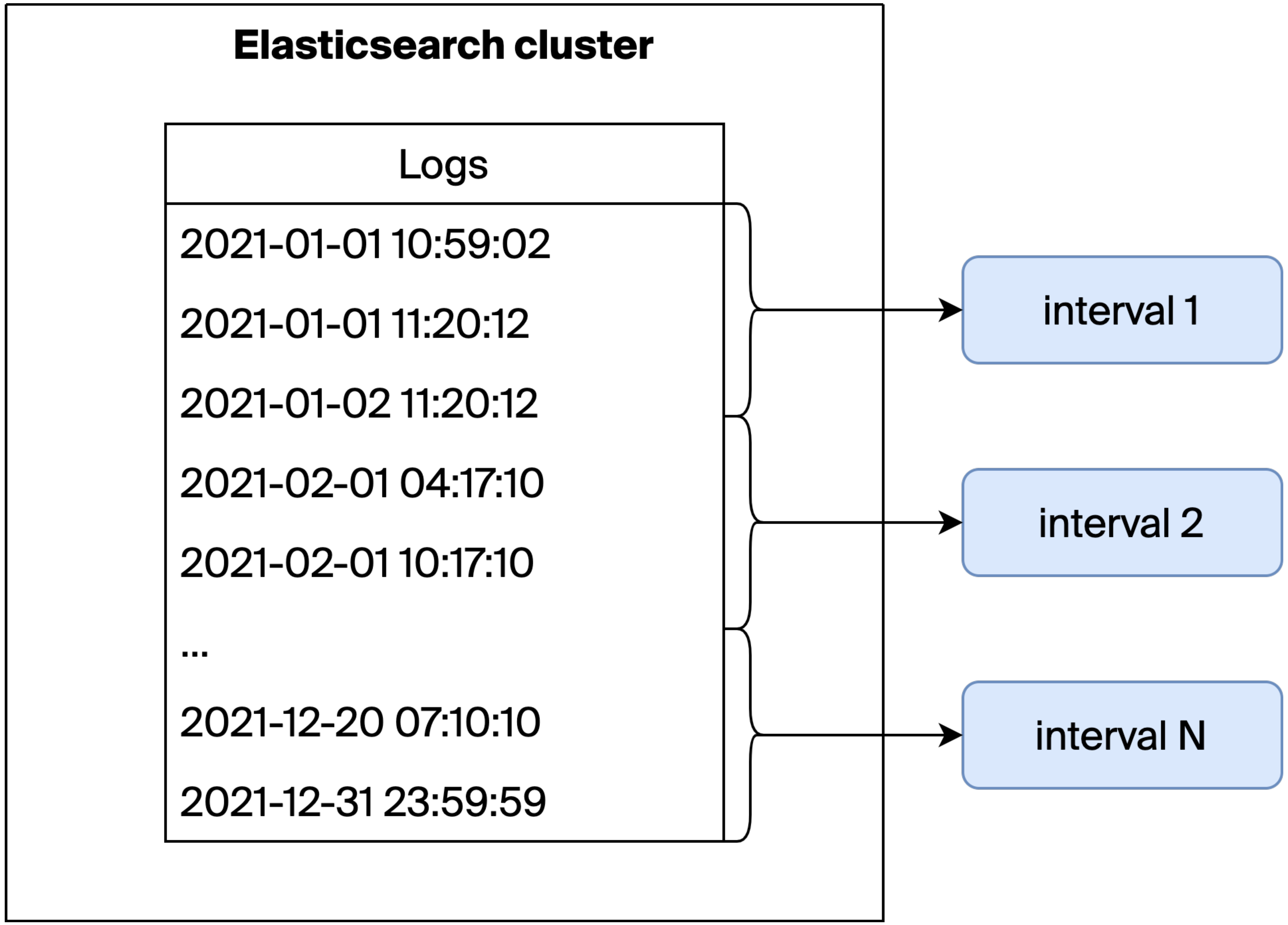
TRANSFER OLD LOGS

WHAT CONCERNED US?

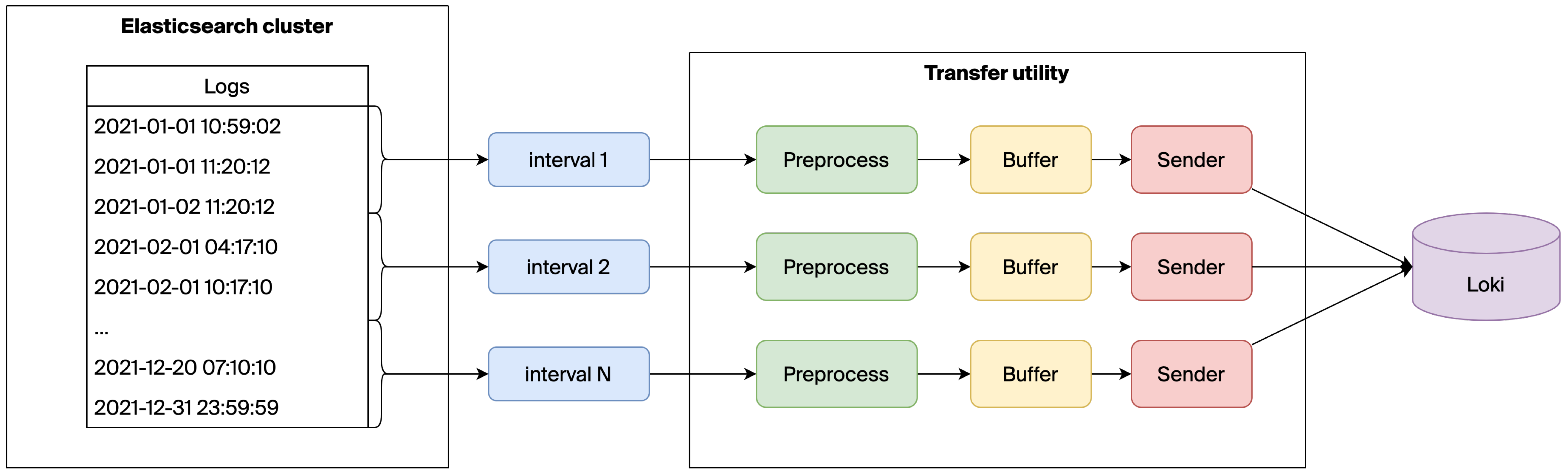
→1 year of log data

→25 TB of storage

INITIAL ASSUMPTION



INITIAL ASSUMPTION



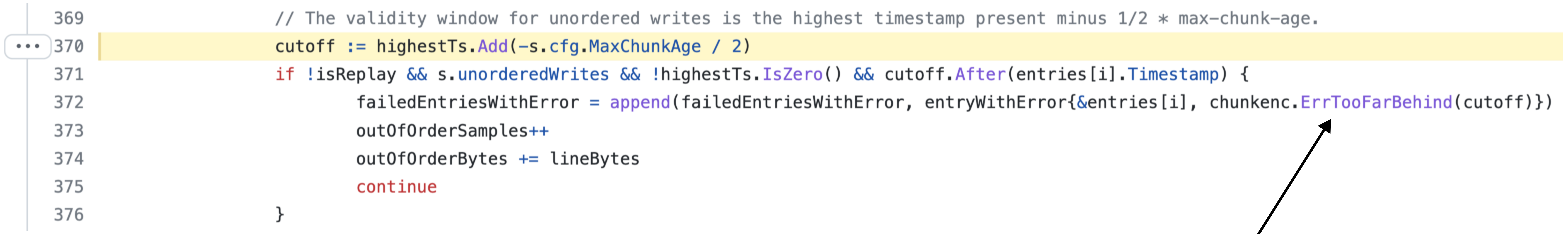
LOKI CONFIG

```yaml
limits_config:
  reject_old_samples: false

  ingestion_rate_mb: 100
  ingestion_burst_size_mb: 30
  per_stream_rate_limit: "150MB"

  max_streams_per_user: 0
  max_global_streams_per_user: 0

  retention_period: 8928h
```

TESTING OUR ASSUMPTION

```
entry too far behind, oldest
acceptable timestamp is:
2021-01-01T01:00:00
```

WHY IS THAT?

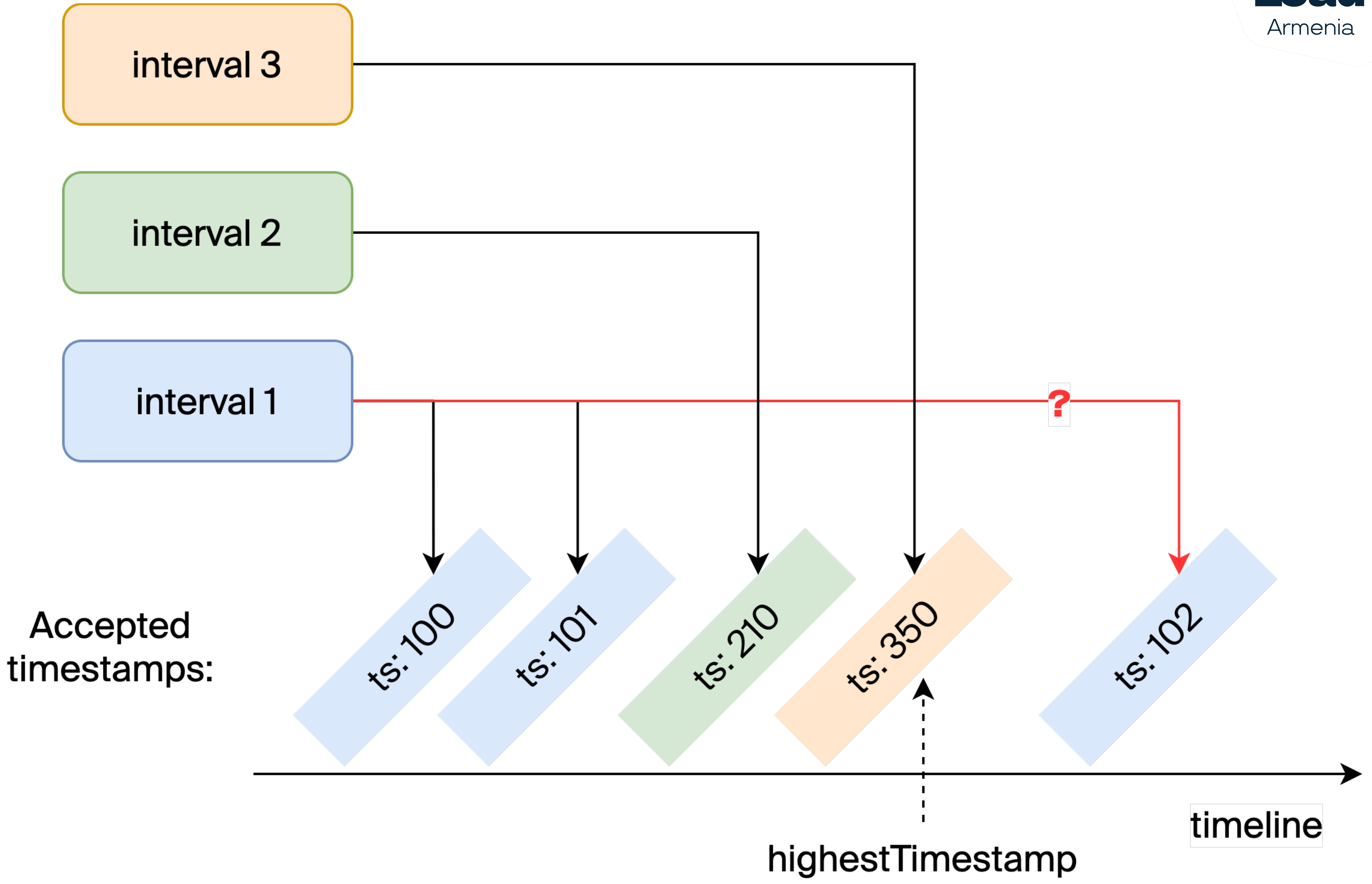


```
        // The validity window for unordered writes is the highest timestamp present minus 1/2 * max-chunk-age.
        cutoff := highestTs.Add(-s.cfg.MaxChunkAge / 2)
        if !isReplay && s.unorderedWrites && !highestTs.IsZero() && cutoff.After(entries[i].Timestamp) {
                failedEntriesWithError = append(failedEntriesWithError, entryWithError{&entries[i], chunkenc.ErrTooFarBehind(cutoff)})
                outOfOrderSamples++
                outOfOrderBytes += lineBytes
                continue
        }
```

This is the error

https://github.com/grafana/loki/blob/c75b822fc6998ca57bf53451ec6dc2038c7c1a5e/pkg/ingester/stream.go#L370

MIND EXPERIMENT



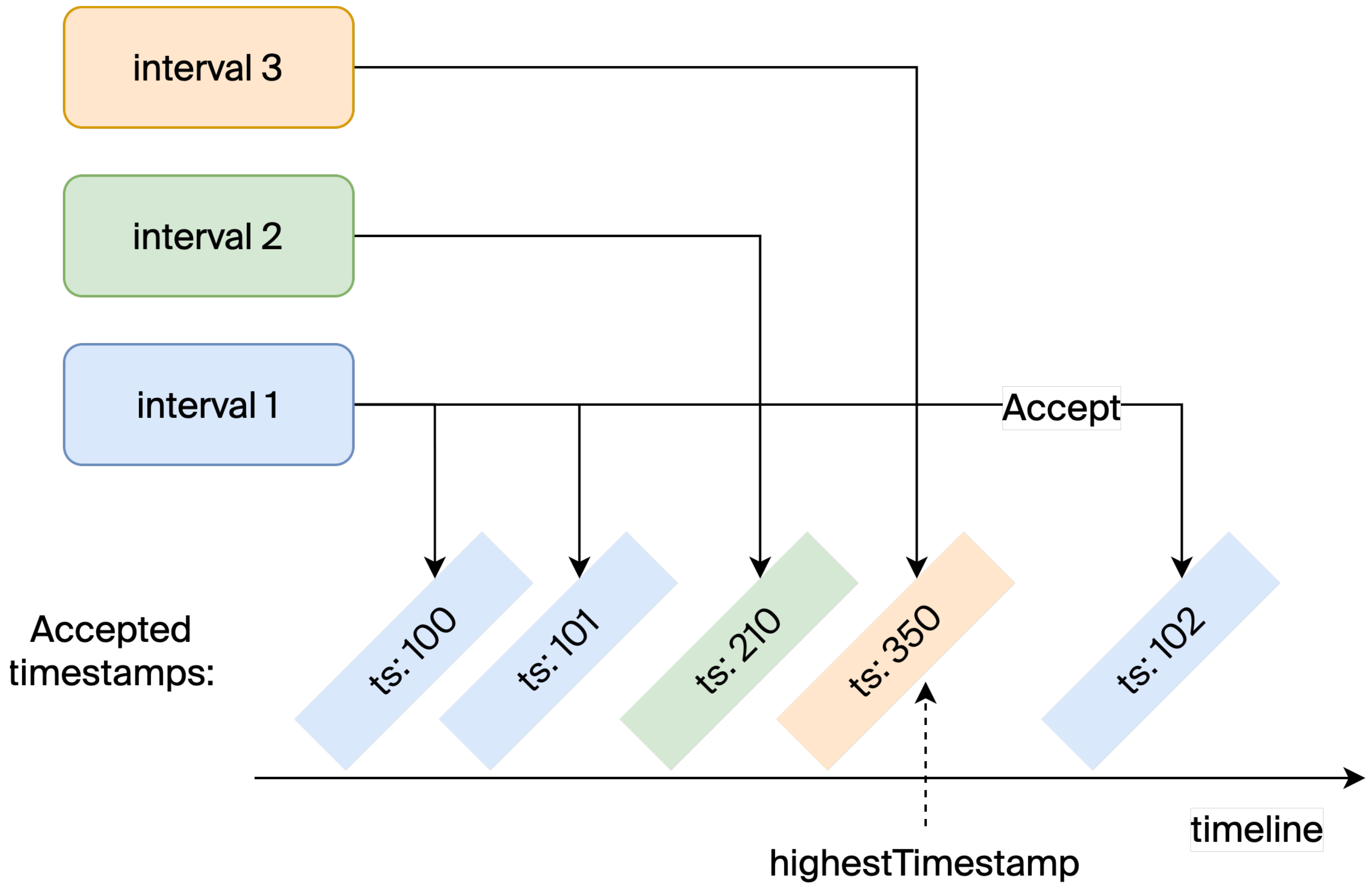
Minimal accepted timestamp is:

```
highestTimestamp - maxChunkAge / 2
```

TWEAK CONFIGURATION

```yaml
ingester:
  max_chunk_age: 8760h # 365d
```

SEEMS TO BE FIXED

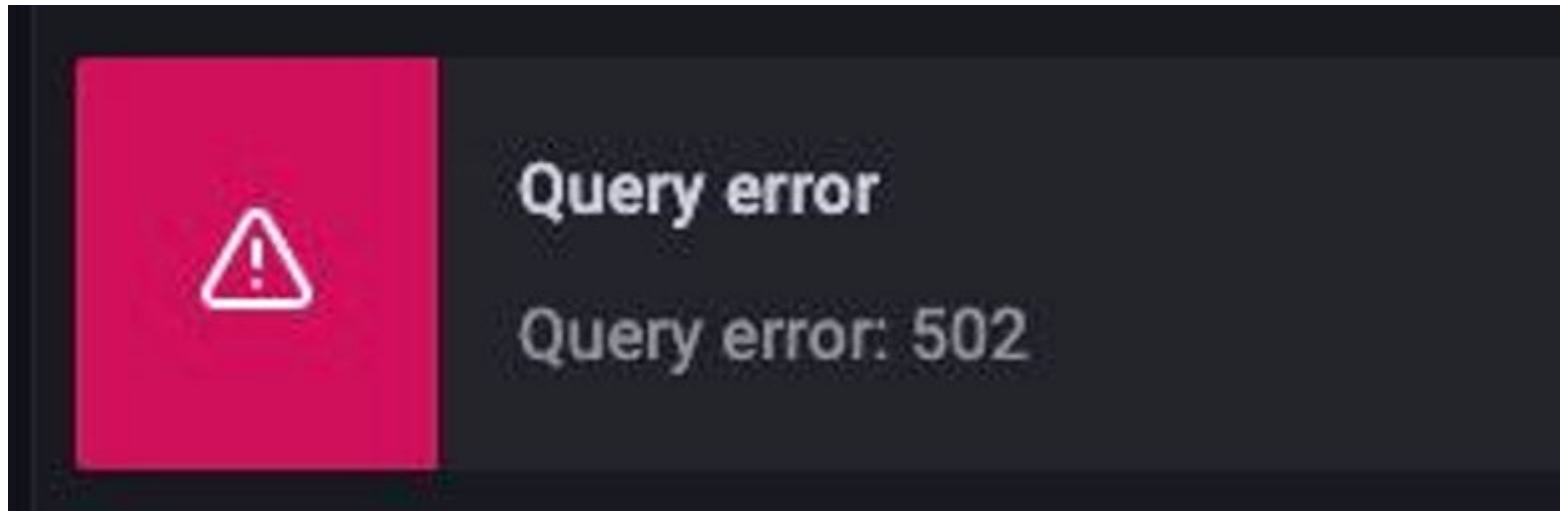


DID WE FOOL LOKI?

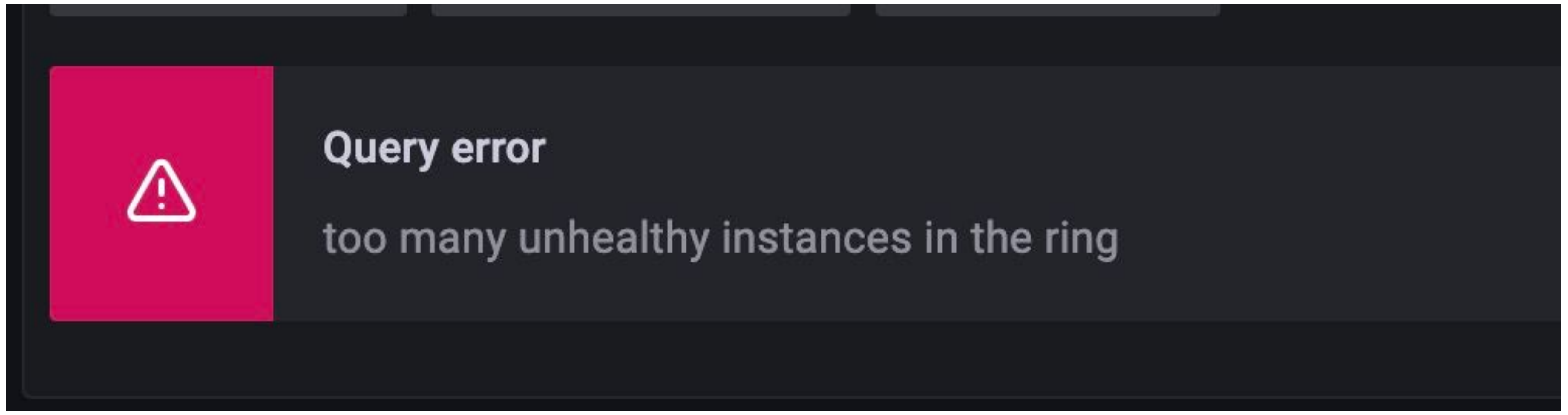
NOT REALLY

LOKI WON

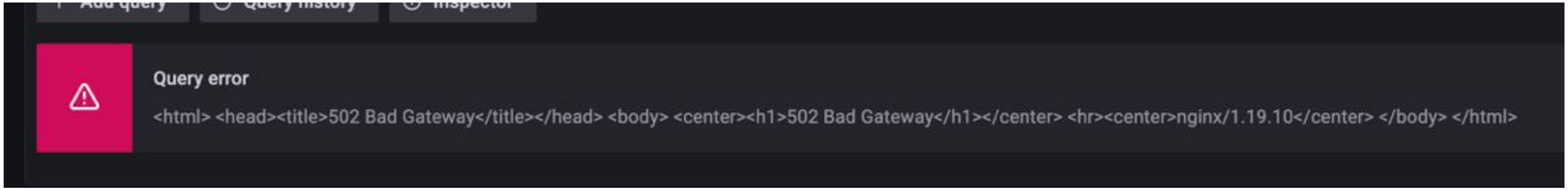
++ High Load Armenia


Query error

Query error: 502


Query error

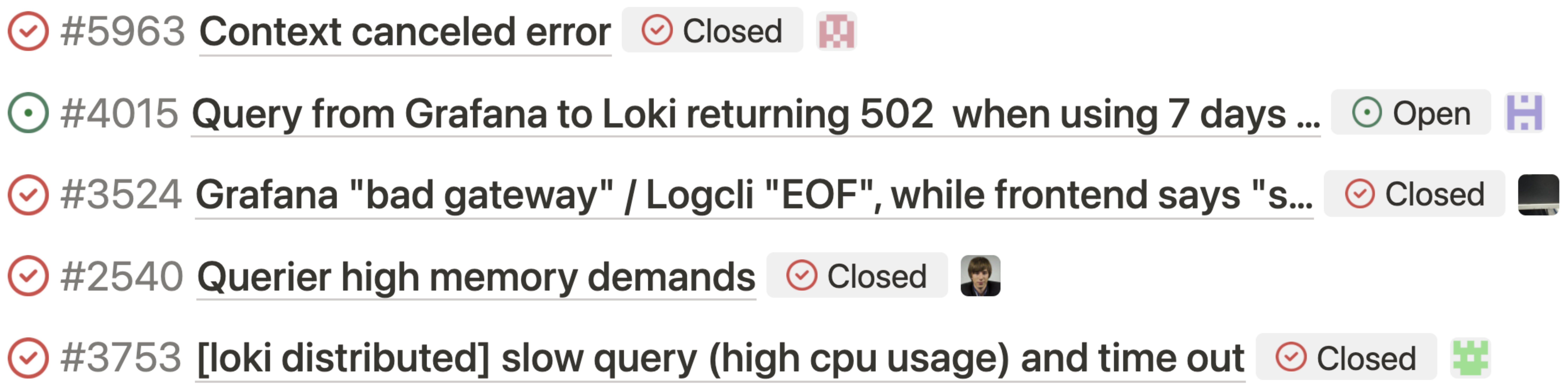
too many unhealthy instances in the ring



Query error

```
<html> <head><title>502 Bad Gateway</title></head> <body> <center><h1>502 Bad Gateway</h1></center> <hr><center>nginx/1.19.10</center> </body> </html>
```

WHAT IS HAPPENING?



- #5963 Context canceled error — Closed
- #4015 Query from Grafana to Loki returning 502 when using 7 days ... — Open
- #3524 Grafana "bad gateway" / Logcli "EOF", while frontend says "s... — Closed
- #2540 Querier high memory demands — Closed
- #3753 [loki distributed] slow query (high cpu usage) and time out — Closed

It is time to stop guessing and start thinking

BLOCK & CHUNK

```
-----------------------------------------------------------------
|    ts (varint)    |     len (uvarint)    |     log-1 bytes     |
-----------------------------------------------------------------
|    ts (varint)    |     len (uvarint)    |     log-2 bytes     |
-----------------------------------------------------------------
|    ts (varint)    |     len (uvarint)    |     log-3 bytes     |
-----------------------------------------------------------------
|    ts (varint)    |     len (uvarint)    |     log-n bytes     |
-----------------------------------------------------------------
```

```
-----------------------------------------------------------------
|                              |                                |
|       MagicNumber(4b)        |          version(1b)           |
|                              |                                |
-----------------------------------------------------------------
|         block-1 bytes        |         checksum (4b)          |
-----------------------------------------------------------------
|         block-2 bytes        |         checksum (4b)          |
-----------------------------------------------------------------
|         block-n bytes        |         checksum (4b)          |
-----------------------------------------------------------------
|                        #blocks (uvarint)                      |
-----------------------------------------------------------------
| #entries(uvarint) | mint, maxt (varint) | offset, len (uvarint) |
-----------------------------------------------------------------
| #entries(uvarint) | mint, maxt (varint) | offset, len (uvarint) |
-----------------------------------------------------------------
| #entries(uvarint) | mint, maxt (varint) | offset, len (uvarint) |
-----------------------------------------------------------------
| #entries(uvarint) | mint, maxt (varint) | offset, len (uvarint) |
-----------------------------------------------------------------
|                      checksum(from #blocks)                   |
-----------------------------------------------------------------
|          metasOffset - offset to the point with #blocks       |
-----------------------------------------------------------------
```

BLOCK & CHUNK

```
-----------------------------------------------------------------
|    ts (varint)    |     len (uvarint)     |     log-1 bytes     |
-----------------------------------------------------------------
|    ts (varint)    |     len (uvarint)     |     log-2 bytes     |
-----------------------------------------------------------------
|    ts (varint)    |     len (uvarint)     |     log-3 bytes     |
-----------------------------------------------------------------
|    ts (varint)    |     len (uvarint)     |     log-n bytes     |
-----------------------------------------------------------------
```

```
--------------------------------------------------------------
|                             |                              |
|       MagicNumber(4b)       |          version(1b)         |
|                             |                              |
--------------------------------------------------------------
|        block-1 bytes        |         checksum (4b)        |
--------------------------------------------------------------
|        block-2 bytes        |         checksum (4b)        |
--------------------------------------------------------------
|        block-n bytes        |         checksum (4b)        |
--------------------------------------------------------------
|                      #blocks (uvarint)                     |
--------------------------------------------------------------
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--------------------------------------------------------------
|                   checksum(from #blocks)                   |
--------------------------------------------------------------
|      metasOffset - offset to the point with #blocks        |
--------------------------------------------------------------
```
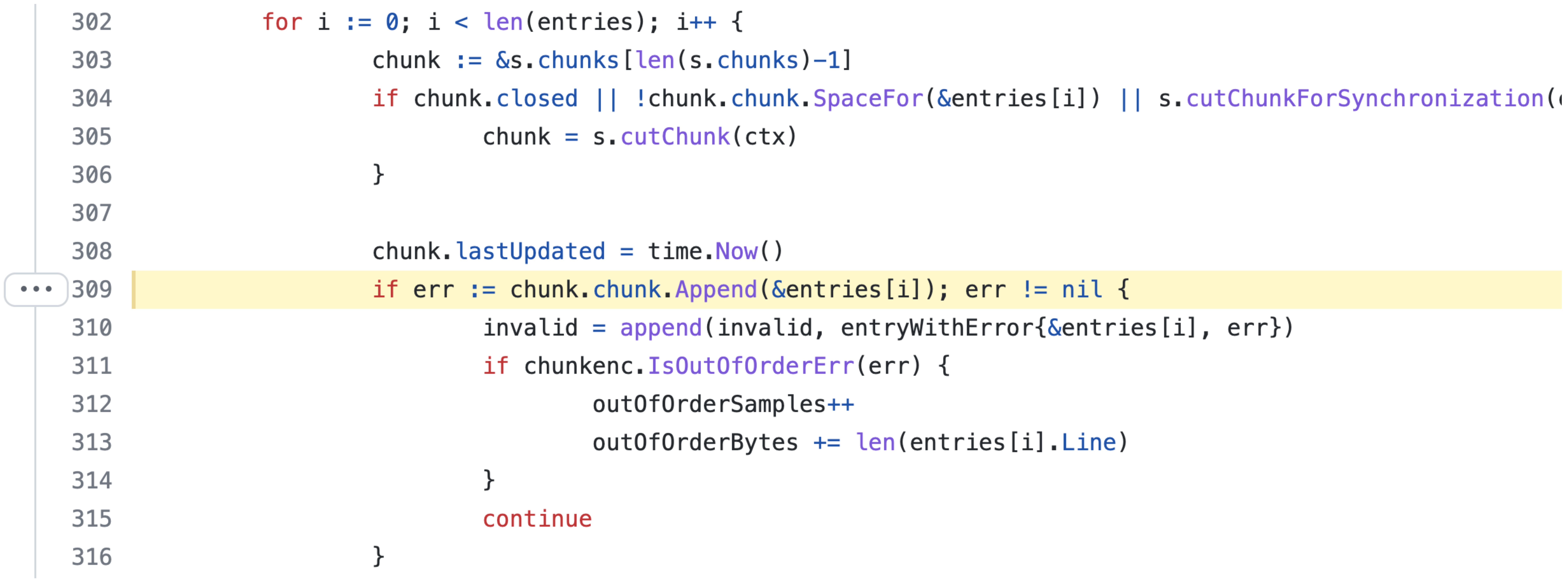
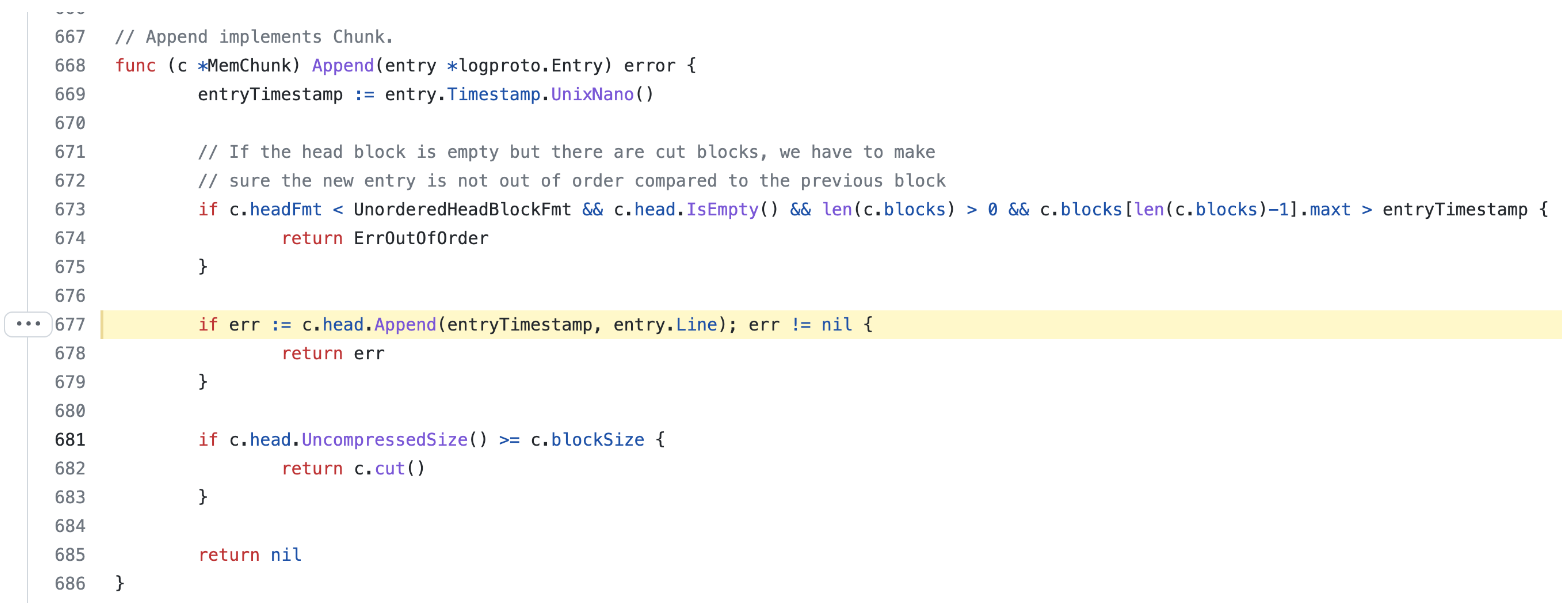

INVESTIGATION STAGE



```
302     for i := 0; i < len(entries); i++ {
303         chunk := &s.chunks[len(s.chunks)-1]
304         if chunk.closed || !chunk.chunk.SpaceFor(&entries[i]) || s.cutChunkForSynchronization(
305             chunk = s.cutChunk(ctx)
306         }
307 
308         chunk.lastUpdated = time.Now()
309         if err := chunk.chunk.Append(&entries[i]); err != nil {
310             invalid = append(invalid, entryWithError{&entries[i], err})
311             if chunkenc.IsOutOfOrderErr(err) {
312                 outOfOrderSamples++
313                 outOfOrderBytes += len(entries[i].Line)
314             }
315             continue
316         }
```

https://github.com/grafana/loki/blob/c75b822fc6998ca57bf53451ec6dc2038c7c1a5e/pkg/ingester/stream.go#L309

INVESTIGATION STAGE

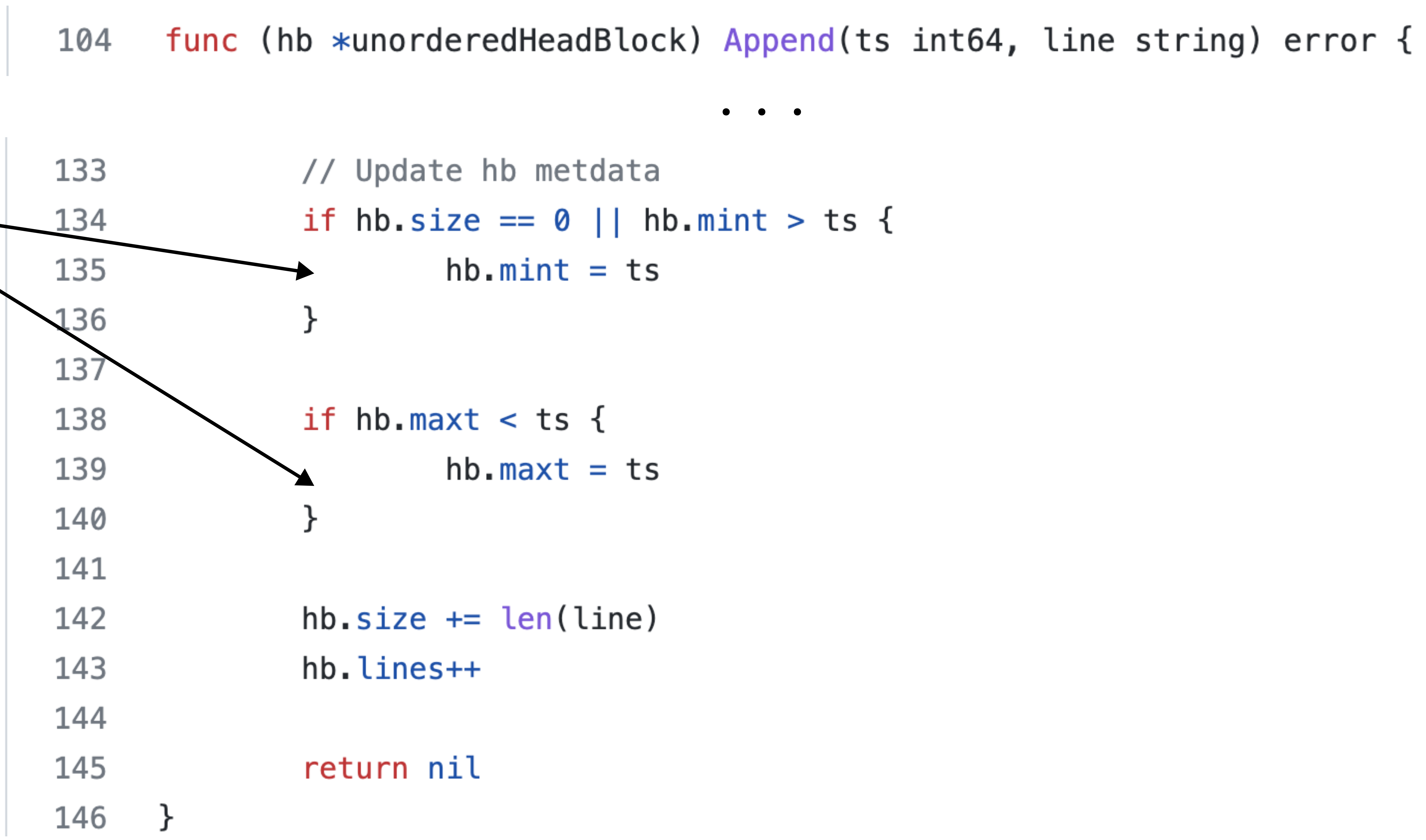


```
667 // Append implements Chunk.
668 func (c *MemChunk) Append(entry *logproto.Entry) error {
669         entryTimestamp := entry.Timestamp.UnixNano()
670
671         // If the head block is empty but there are cut blocks, we have to make
672         // sure the new entry is not out of order compared to the previous block
673         if c.headFmt < UnorderedHeadBlockFmt && c.head.IsEmpty() && len(c.blocks) > 0 && c.blocks[len(c.blocks)-1].maxt > entryTimestamp {
674                 return ErrOutOfOrder
675         }
676
677         if err := c.head.Append(entryTimestamp, entry.Line); err != nil {
678                 return err
679         }
680
681         if c.head.UncompressedSize() >= c.blockSize {
682                 return c.cut()
683         }
684
685         return nil
686 }
```

https://github.com/grafana/loki/blob/c75b822fc6998ca57bf53451ec6dc2038c7c1a5e/pkg/chunkenc/memchunk.go#L677

INVESTIGATION STAGE

It just updates the boundaries

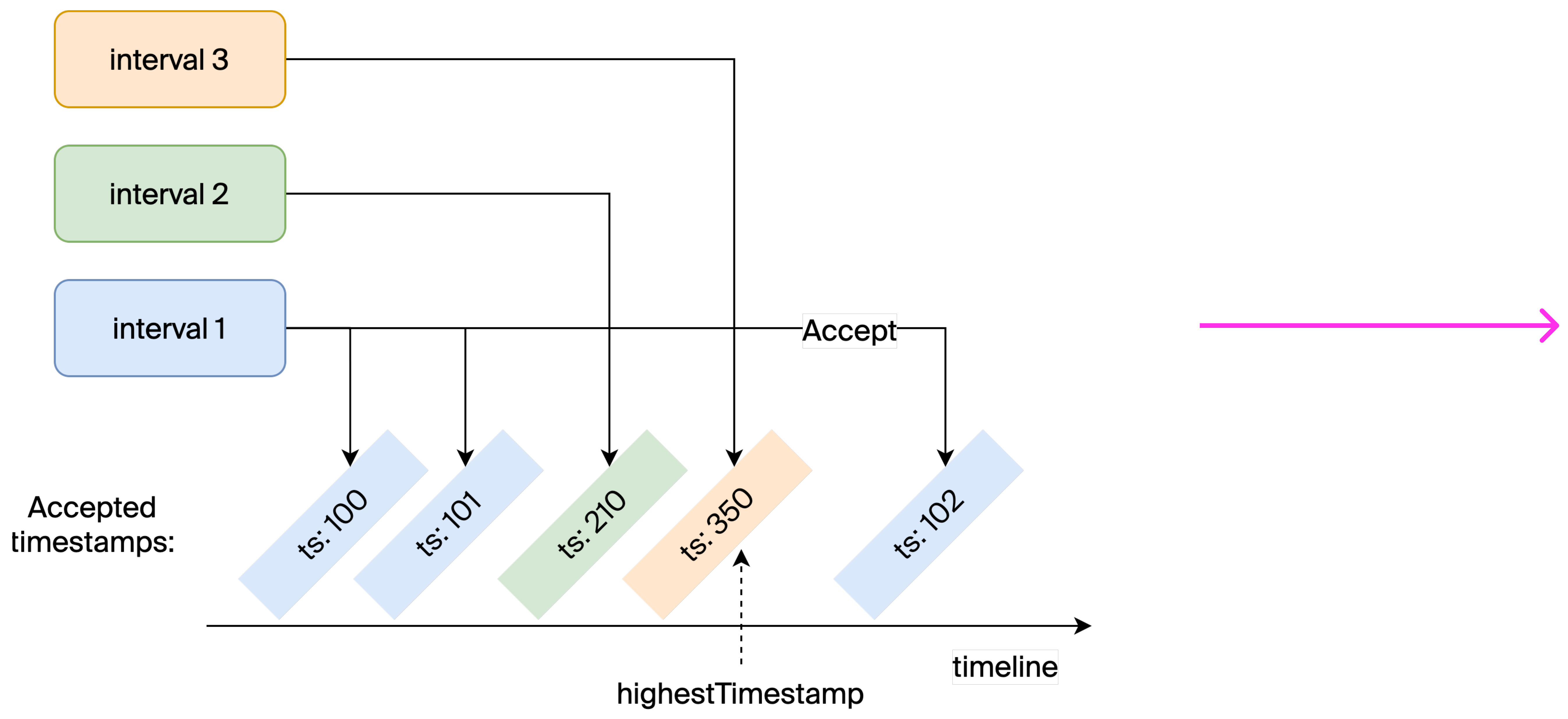


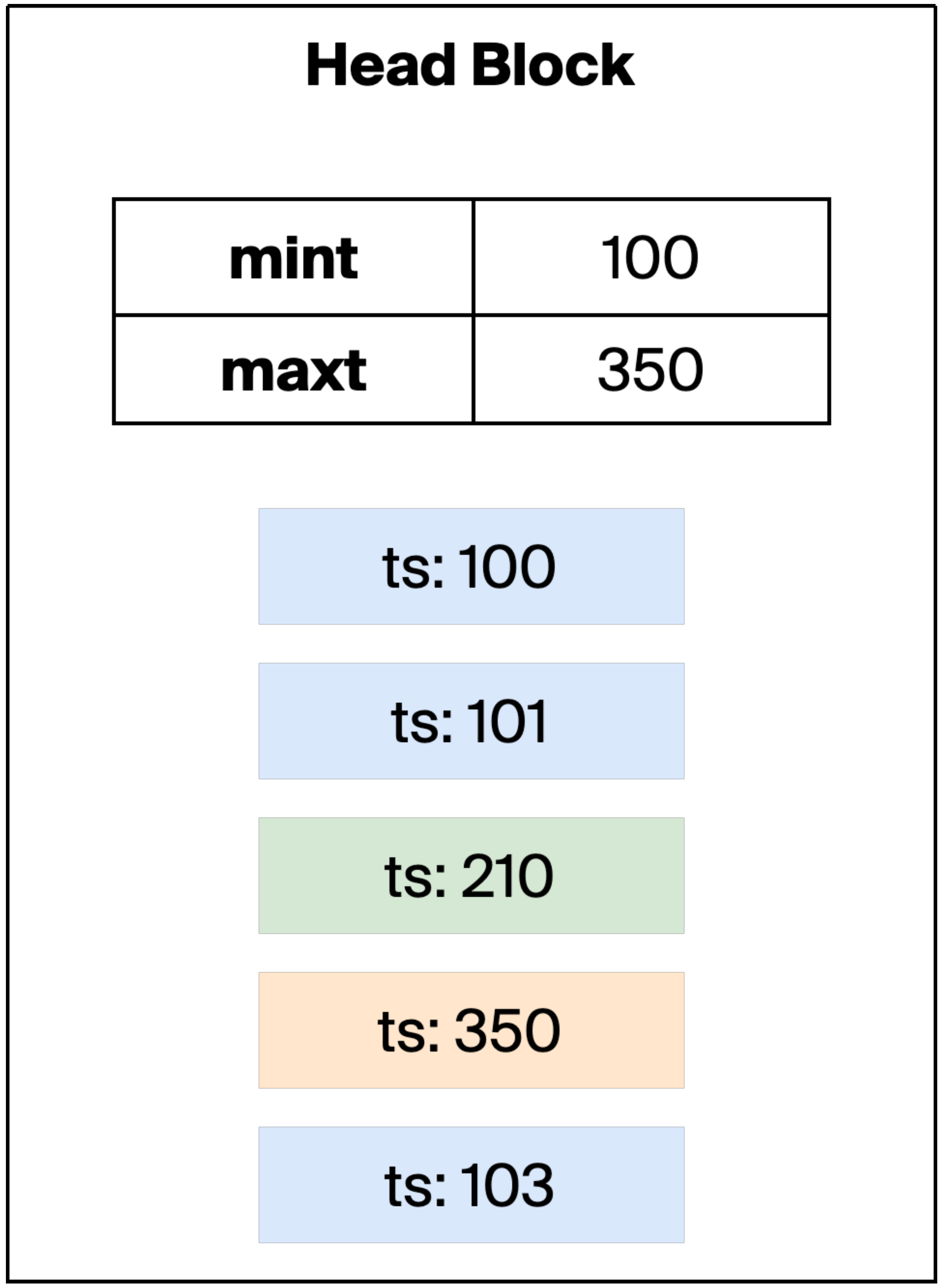
```go
func (hb *unorderedHeadBlock) Append(ts int64, line string) error {
                                        . . .

	// Update hb metdata
	if hb.size == 0 || hb.mint > ts {
		hb.mint = ts
	}

	if hb.maxt < ts {
		hb.maxt = ts
	}

	hb.size += len(line)
	hb.lines++

	return nil
}
```

https://github.com/grafana/loki/blob/c75b822fc6998ca57bf53451ec6dc2038c7c1a5e/pkg/chunkenc/unordered.go#L104

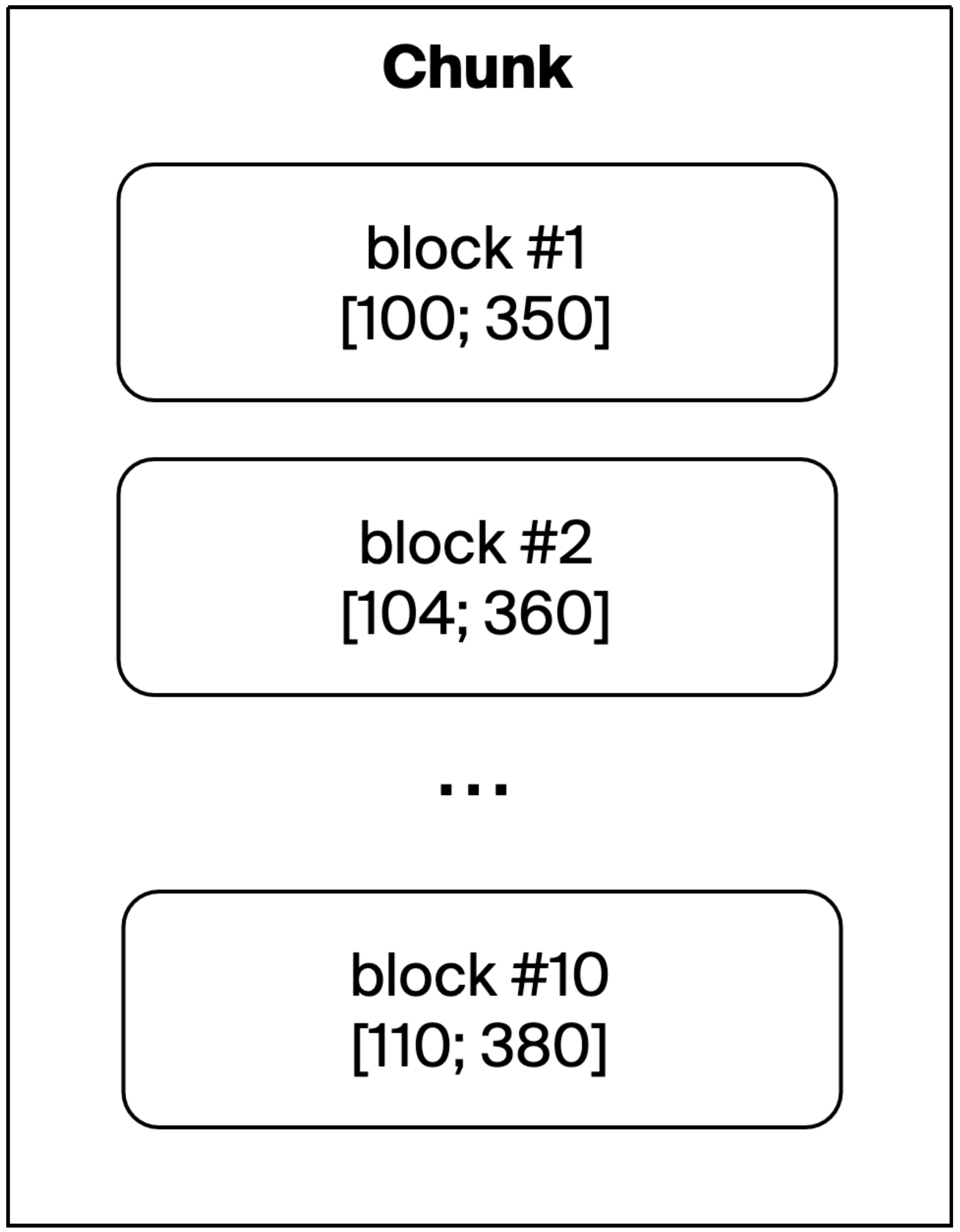
SO WHAT?

BLOCKS MIX UP

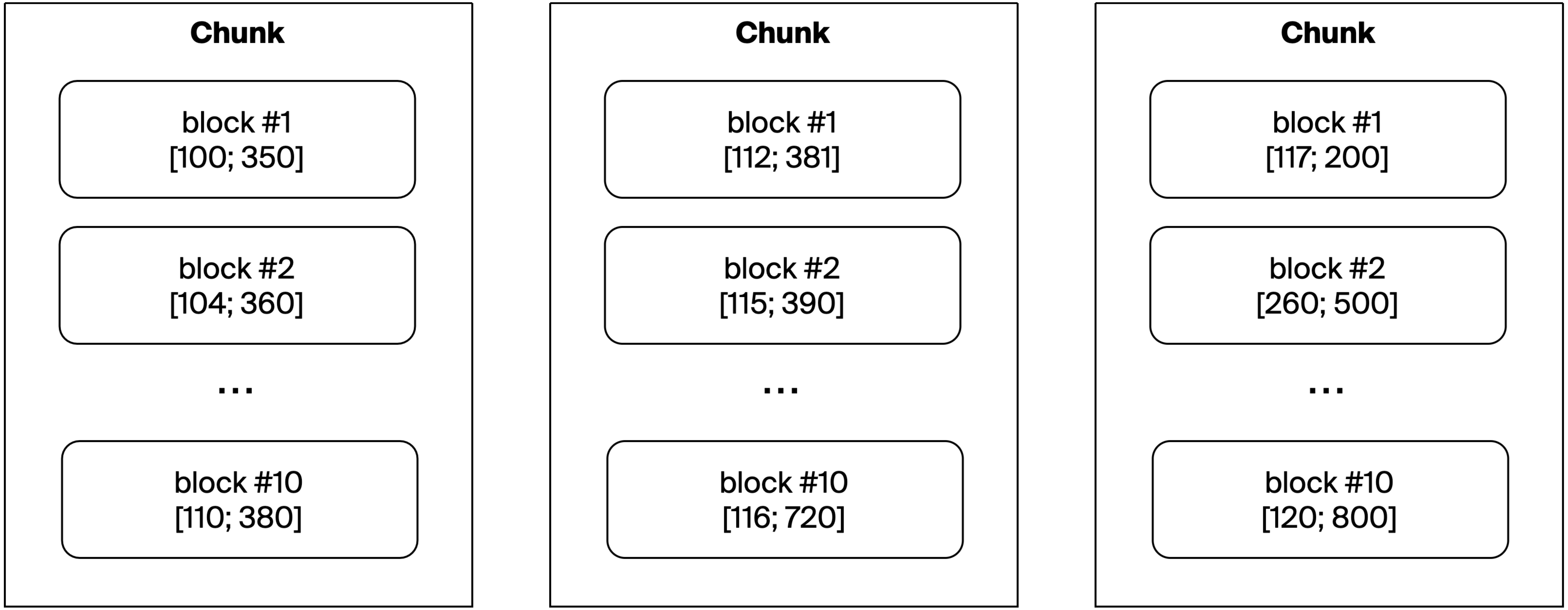




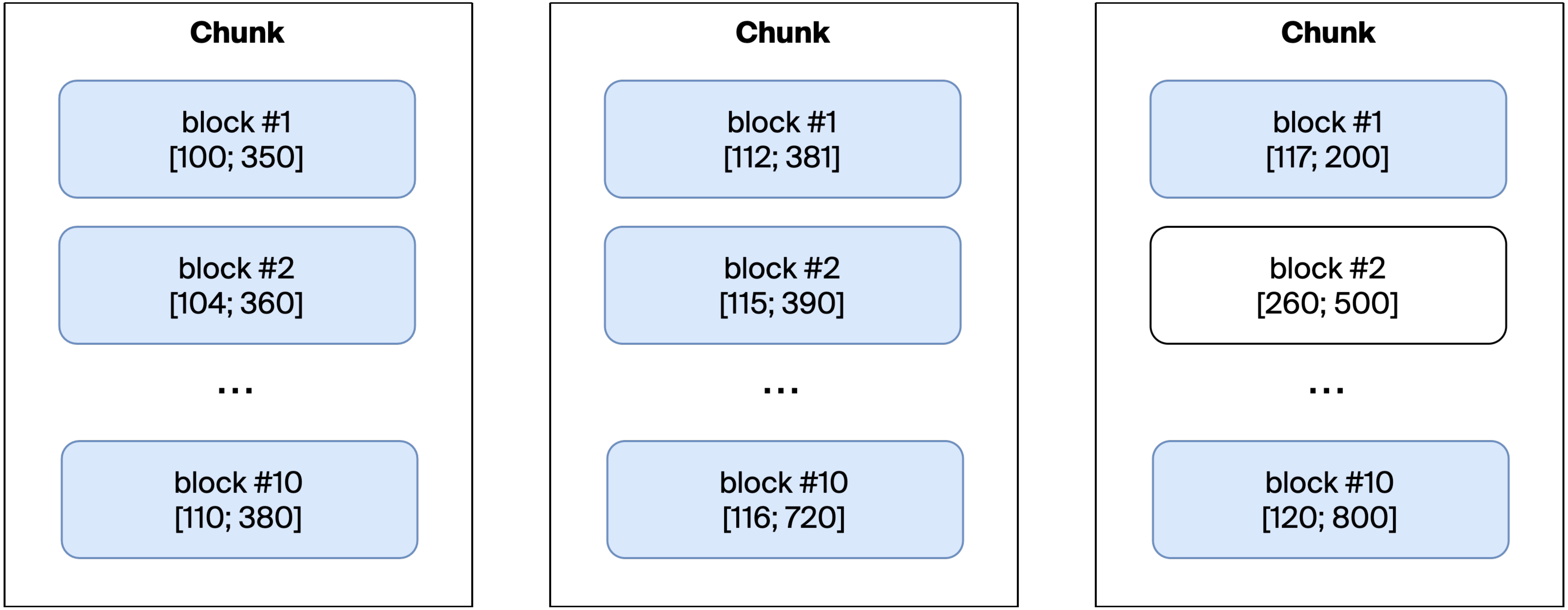
mint	100
maxt	350


Chunk
block #1
[100; 350]
block #2
[104; 360]
...
block #10
[110; 380]

CHUNKS MIX UP AS WELL

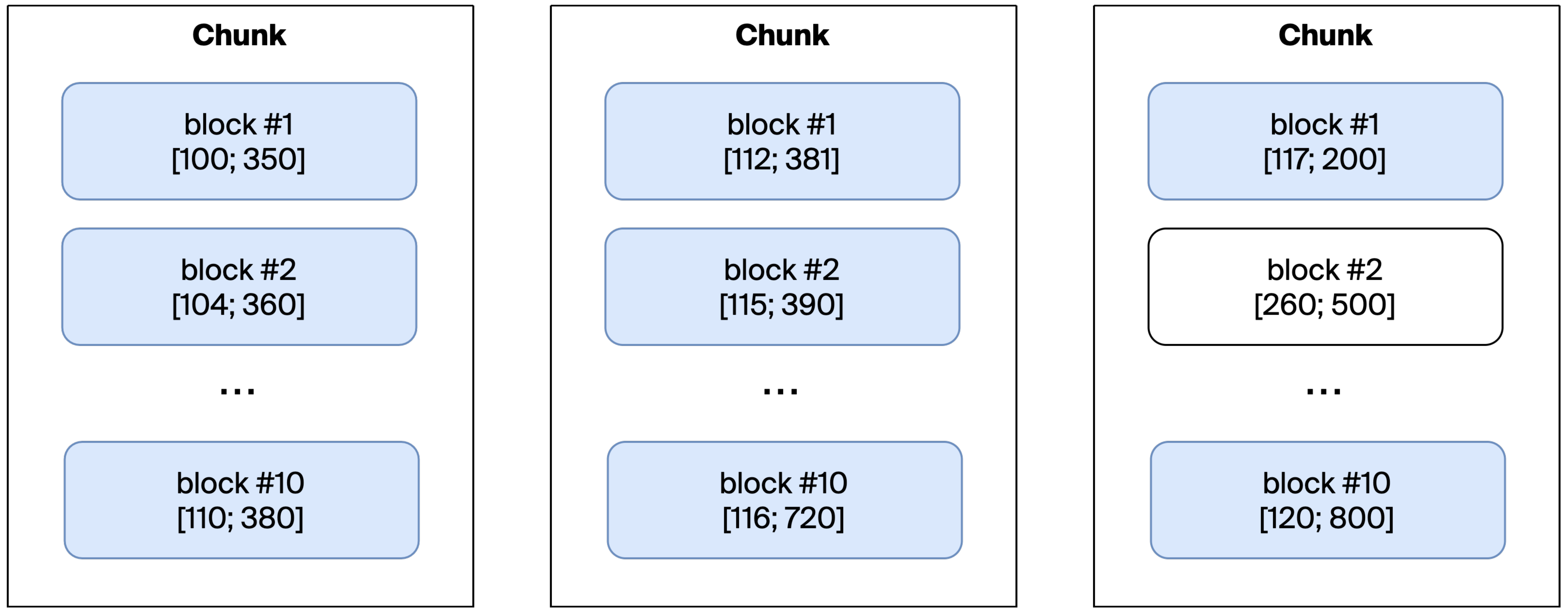


QUERY LOGS IN [120;200]



QUERY LOGS IN [120;200]

- Loki is forced to download almost all chunks from the storage
- Process in memory
- Resort & filter



QUERY LOGS IN [120;200]

- Loki is forced to download almost all chunks from the storage
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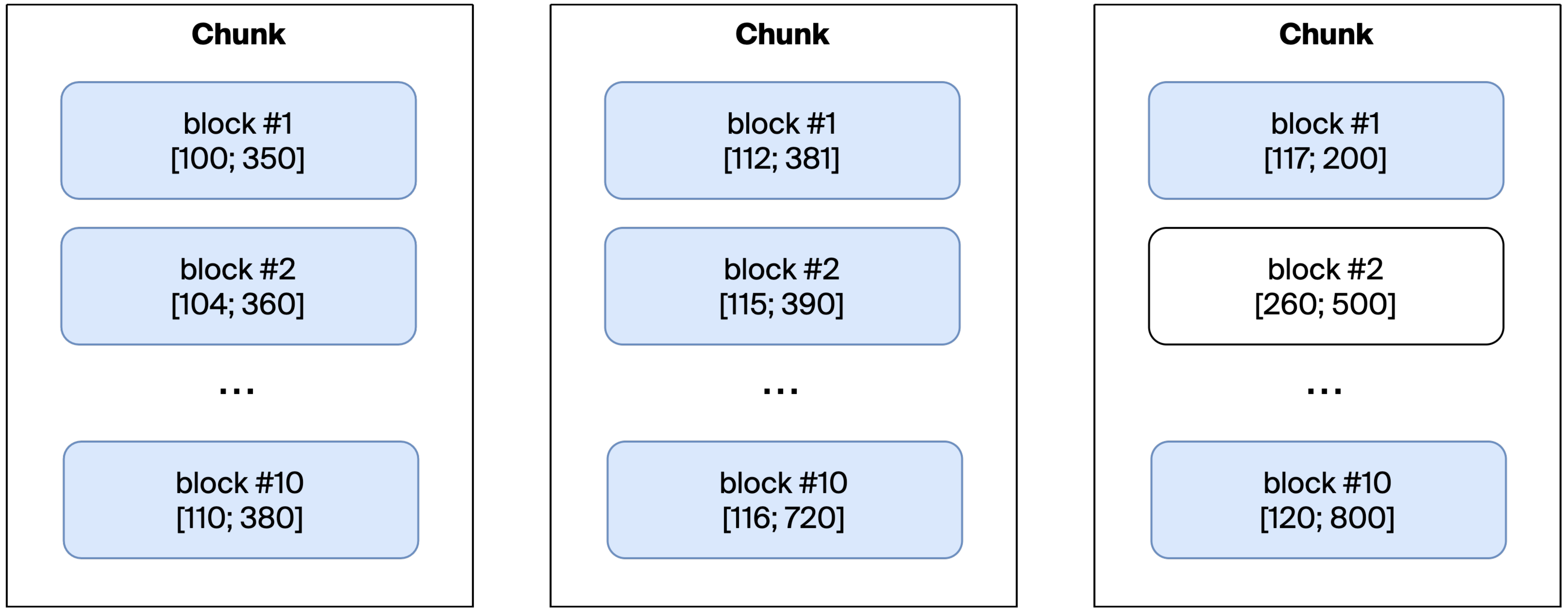
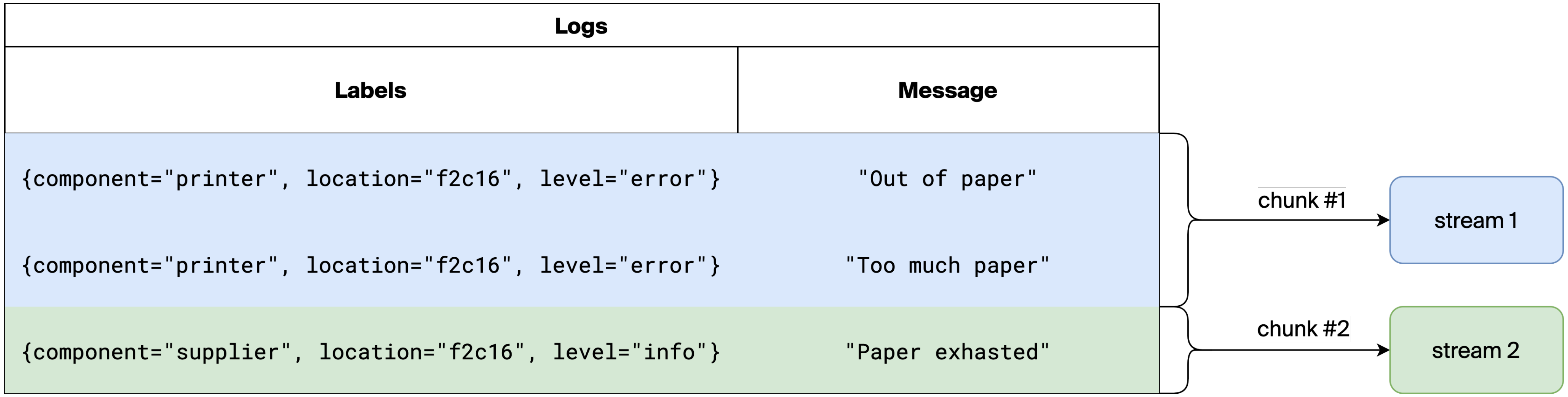
- Resort & filter



https://github.com/grafana/loki/issues/2540

HOW TO FIX EVERYTHING?



Logs	
Labels	**Message**
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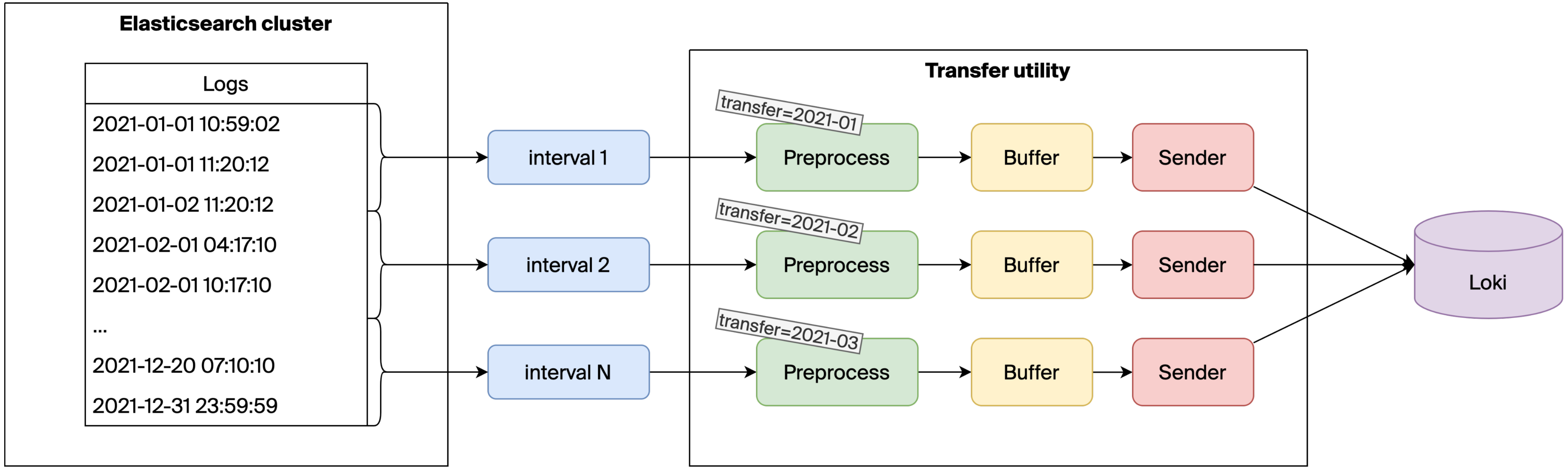
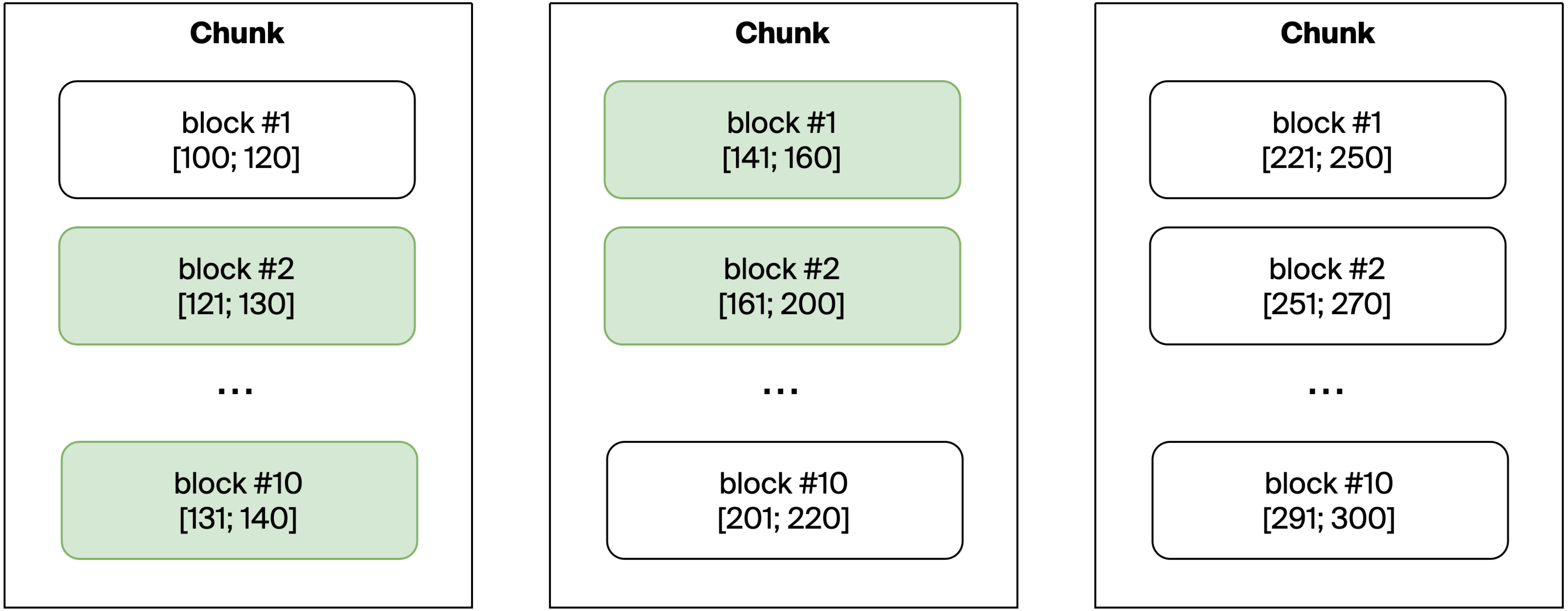
HOW TO FIX EVERYTHING?

1. Don’t set **max_chunk_age** to a high value
2. Don’t send logs in **parallel** for the same set of labels (i.e. a stream)
3. You may create **additional streams** by adding new labels
4. Send logs within a stream only in the **strict order**

JUST ADD LABELS



QUERY LOGS IN [120; 200]



CHUNKS SITUATION

1 Query matches less chunks

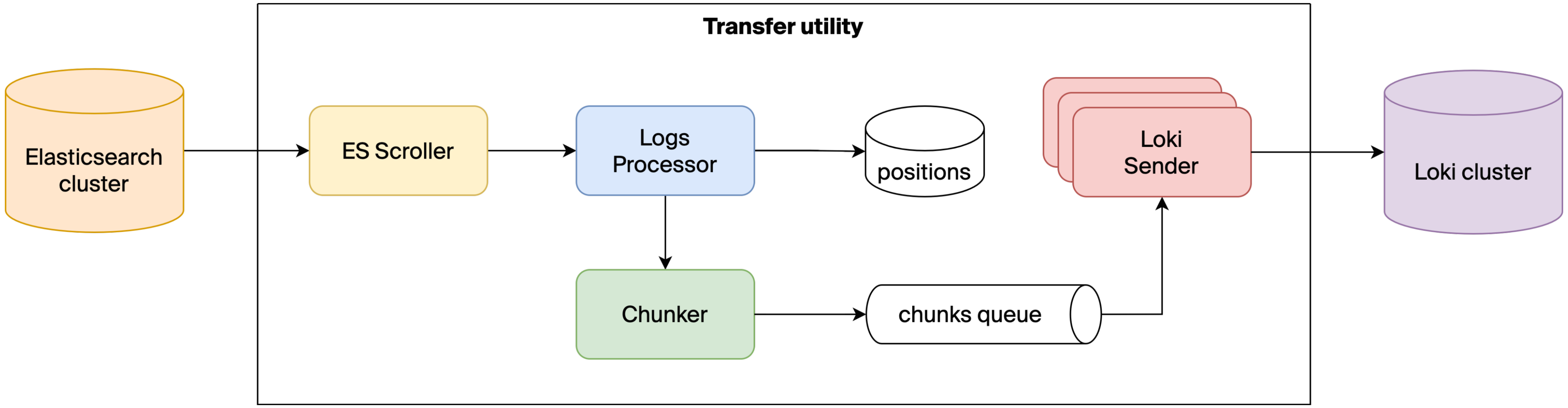
↘

2 All blocks within all chunks are strictly ordered

↘

3 Fast and efficient query execution

TRANSFER IMPLEMENTATION


Transfer utility
Elasticsearch cluster
ES Scroller
Logs Processor
positions
Chunker
chunks queue
Loki Sender
Loki cluster

ES SCROLLER

1. Sort by (@timestamp, log.offset)
2. Use search_after to scroll & resume search
3. Do not let a consumer wait for data
4. Handle errors properly
5. Some shards may return no data

ALWAYS WAIT FOR ERROR RESOLUTION - WE CANNOT LOOSE LOG LINES

LOGS PROCESSOR

PERFORMS A SIMILAR PROCESSING AS PROMTAIL

1. Extract timestamp
2. Extract labels
3. Filter logs
4. Make a unique stream to ensure parallelism

LOGS PROCESSOR

```python
class Transfer(BaseTransfer):
    def extract_doc_labels(self, source: dict) → Optional[MutableMapping[str, str]]:
        return dict(
            app=source.get("fields", {}).get("service_name"),
            job="logs",
            level=source.get("level"),
            node_name=source.get("host", {}).get("name"),
            logger_name=source.get("logger_name"),
        )
```

LOKI SENDER

1. Send data to /loki/api/v1/push
2. Send data sequentially
3. Use only 1 worker (for now)
4. Support for different protocols

LOKI SENDER

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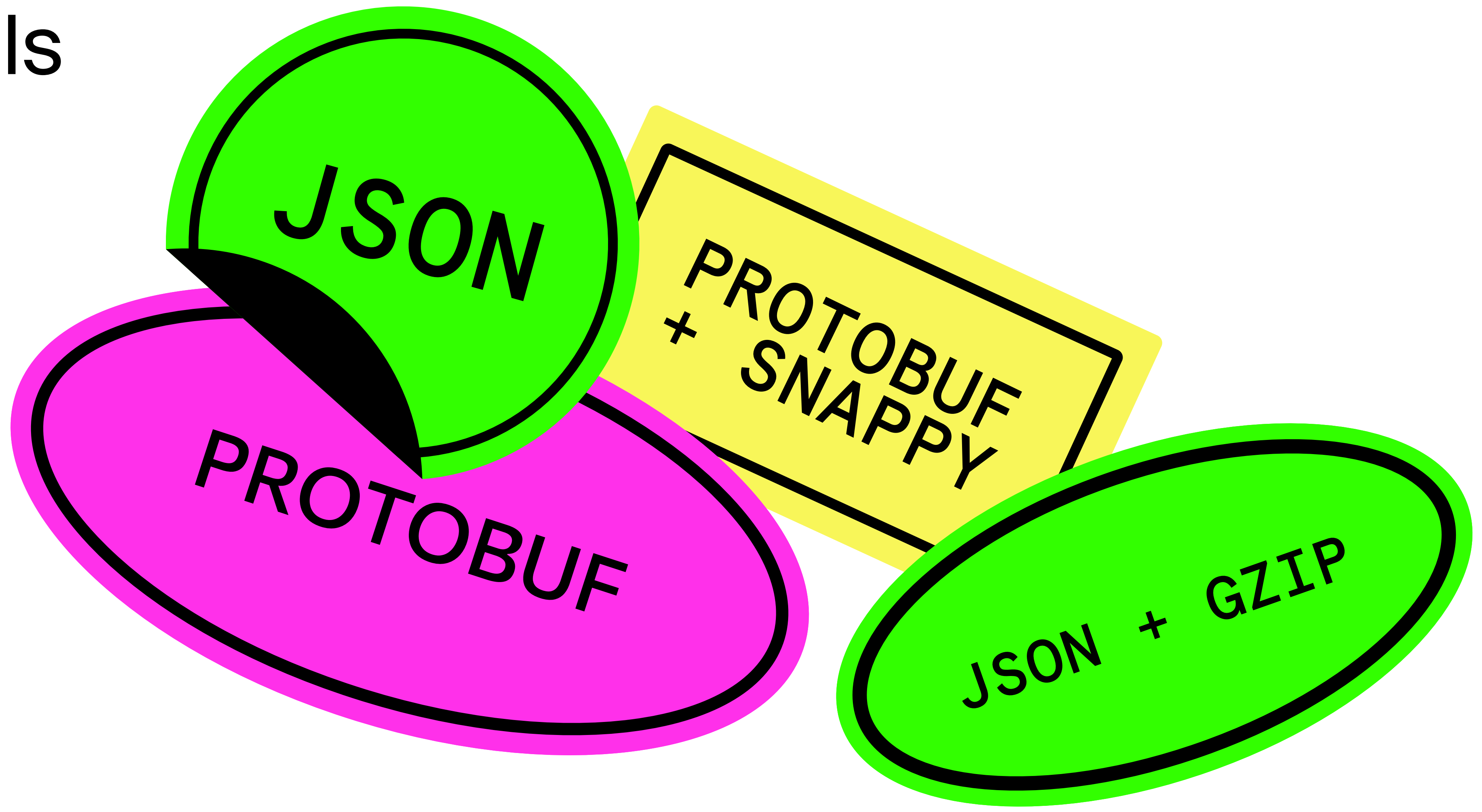

YOU CAN ALREADY USE IT

HTTPS://GITHUB.COM/KTSSTUDIO/ES2LOKI

YOU CAN ALREADY USE IT

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            node_name=source.get("host", {}).get("name"),
            logger_name=source.get("logger_name"),
        )
```

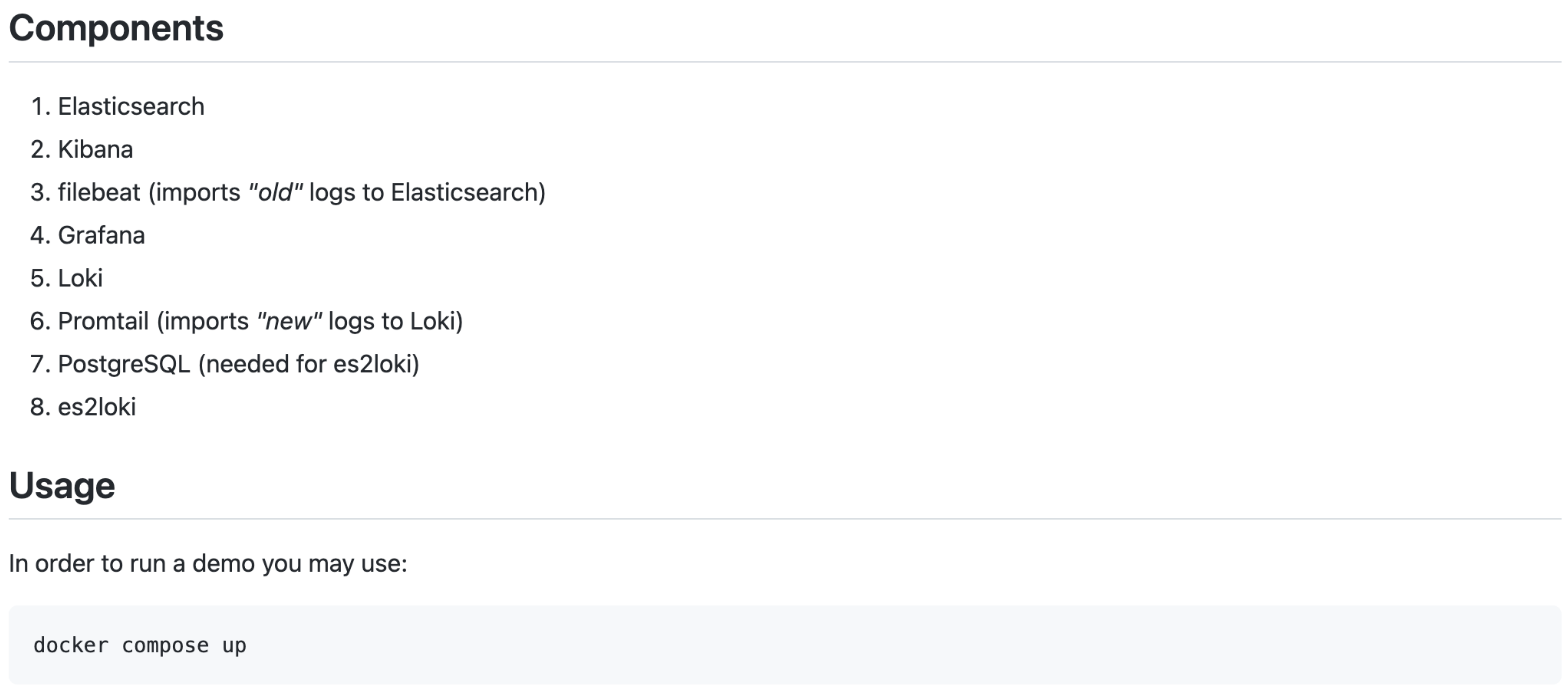
```
ELASTIC_HOSTS=http://localhost:9200 \
ELASTIC_INDEX="filebeat-*" \
LOKI_URL=http://localhost:3100 \
python ./transfer.py
```

YOU CAN ALREADY USE IT

JUST ADD YOUR OWN DOCKER IMAGE, WE'LL DO THE REST:

```
$ helm repo add kts https://charts.kts.studio
$ helm repo update
$ helm upgrade --install \
  RELEASE_NAME \
  kts/es2loki \
  --set image.repository=your-docker-image
  --set image.tag=latest
```

SEE HOW IT WORKS



Components

1. Elasticsearch
2. Kibana
3. filebeat (imports *"old"* logs to Elasticsearch)
4. Grafana
5. Loki
6. Promtail (imports *"new"* logs to Loki)
7. PostgreSQL (needed for es2loki)
8. es2loki

Usage

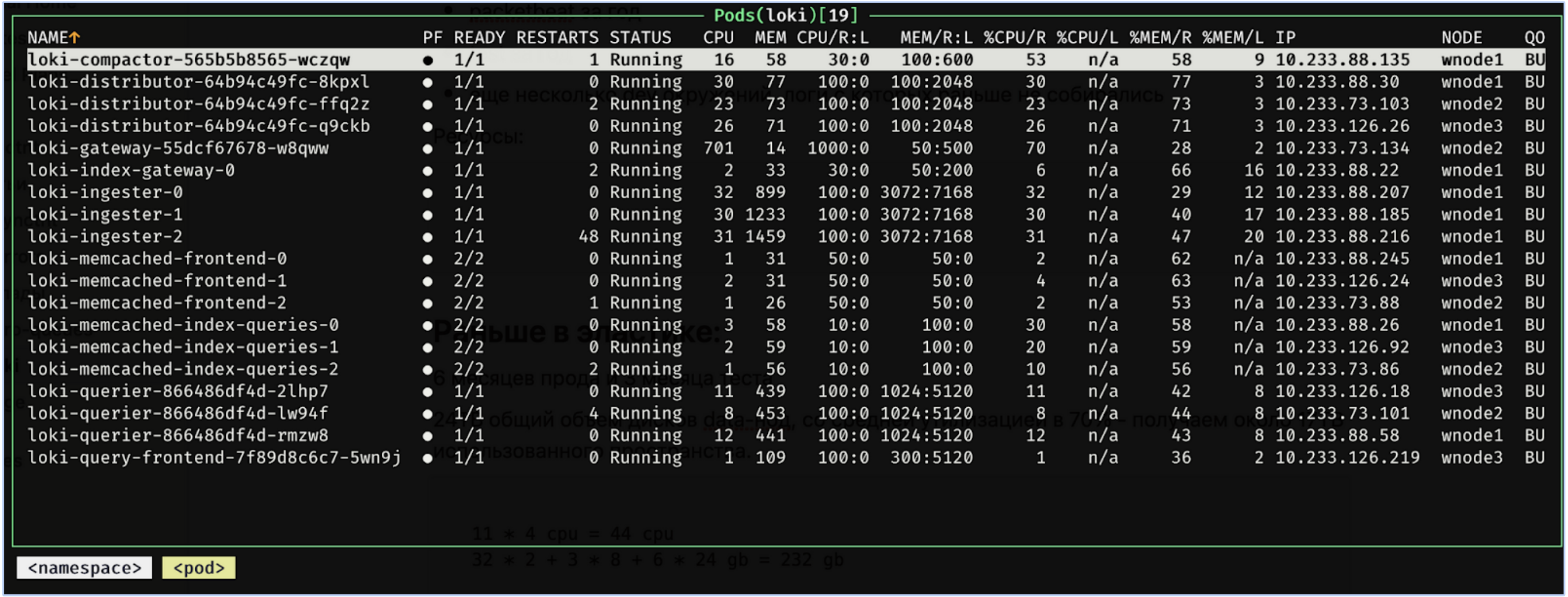
In order to run a demo you may use:

```
docker compose up
```

HTTPS://GITHUB.COM/KTSSTUDIO/ES2LOKI

ANY PROFIT?

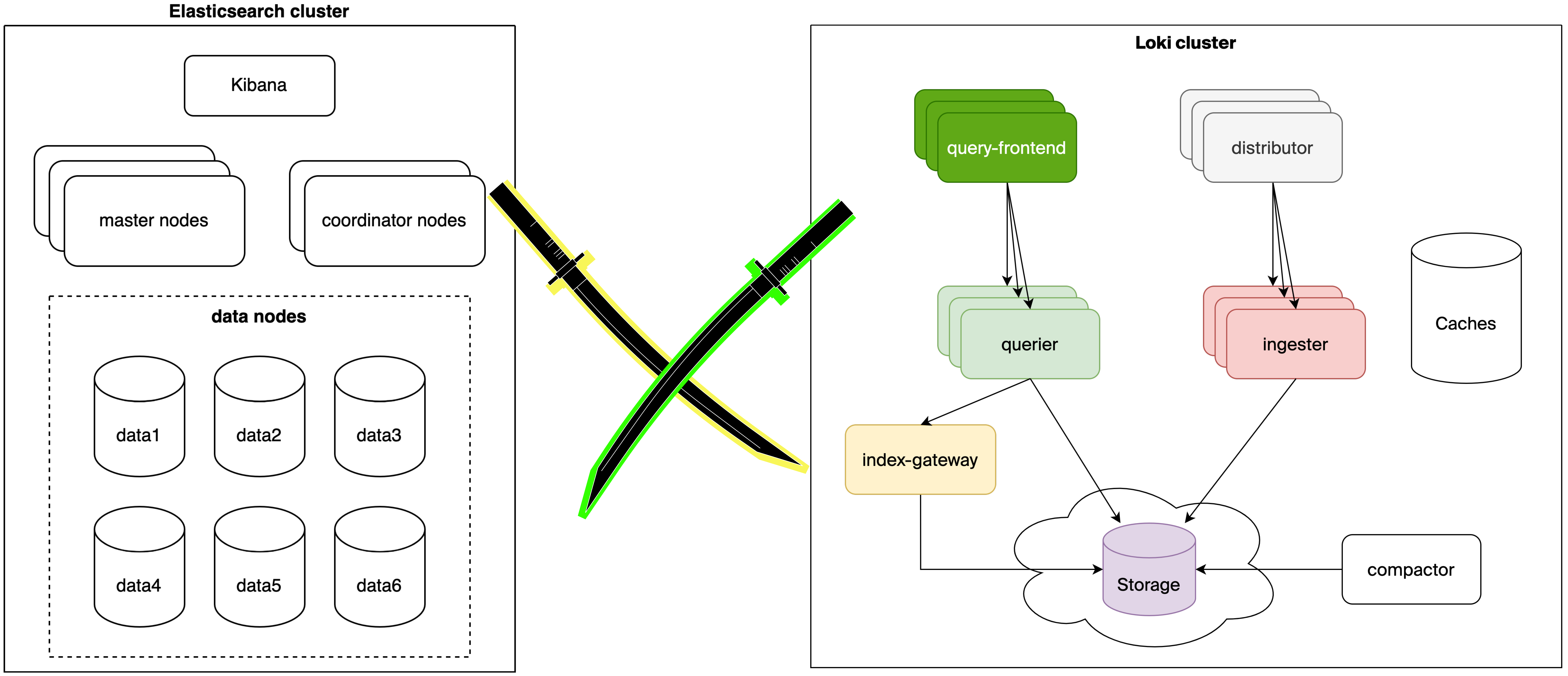
LOKI IN KUBERNETES



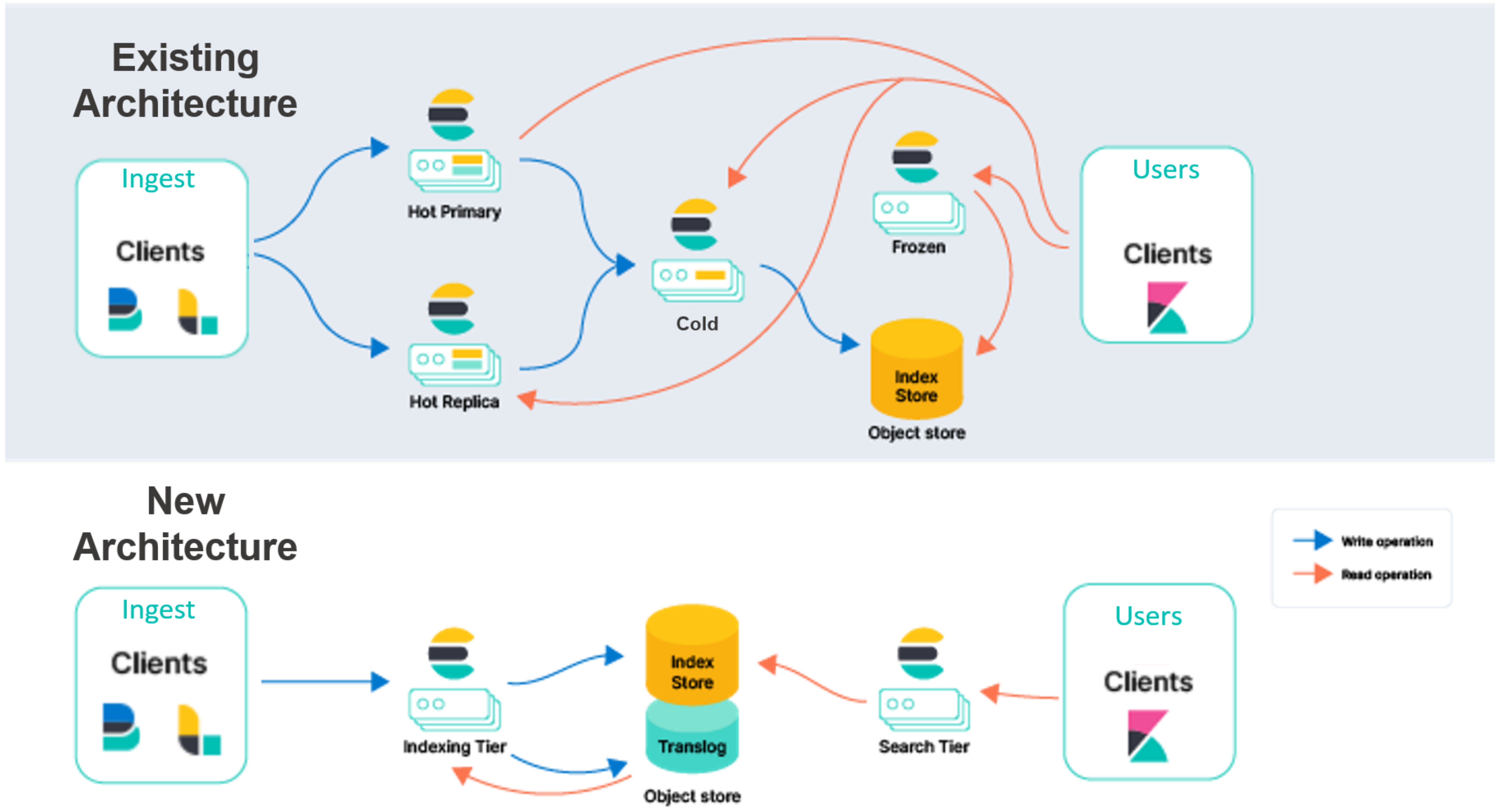
```
Pods(loki)[19]
NAME↑                               PF READY RESTARTS STATUS   CPU  MEM CPU/R:L    MEM/R:L %CPU/R %CPU/L %MEM/R %MEM/L IP              NODE   QO
loki-compactor-565b5b8565-wczqw     ●  1/1          1 Running   16   58    30:0    100:600     53    n/a     58      9 10.233.88.135   wnode1 BU
loki-distributor-64b94c49fc-8kpxl   ●  1/1          0 Running   30   77   100:0   100:2048     30    n/a     77      3 10.233.88.30    wnode1 BU
loki-distributor-64b94c49fc-ffq2z   ●  1/1          2 Running   23   73   100:0   100:2048     23    n/a     73      3 10.233.73.103   wnode2 BU
loki-distributor-64b94c49fc-q9ckb   ●  1/1          0 Running   26   71   100:0   100:2048     26    n/a     71      3 10.233.126.26   wnode3 BU
loki-gateway-55dcf67678-w8qww       ●  1/1          0 Running  701   14  1000:0     50:500     70    n/a     28      2 10.233.73.134   wnode2 BU
loki-index-gateway-0                ●  1/1          2 Running    2   33    30:0     50:200      6    n/a     66     16 10.233.88.22    wnode1 BU
loki-ingester-0                     ●  1/1          0 Running   32  899   100:0  3072:7168     32    n/a     29     12 10.233.88.207   wnode1 BU
loki-ingester-1                     ●  1/1          0 Running   30 1233   100:0  3072:7168     30    n/a     40     17 10.233.88.185   wnode1 BU
loki-ingester-2                     ●  1/1         48 Running   31 1459   100:0  3072:7168     31    n/a     47     20 10.233.88.216   wnode1 BU
loki-memcached-frontend-0           ●  2/2          0 Running    1   31    50:0       50:0      2    n/a     62    n/a 10.233.88.245   wnode1 BU
loki-memcached-frontend-1           ●  2/2          0 Running    2   31    50:0       50:0      4    n/a     63    n/a 10.233.126.24   wnode3 BU
loki-memcached-frontend-2           ●  2/2          1 Running    1   26    50:0       50:0      2    n/a     53    n/a 10.233.73.88    wnode2 BU
loki-memcached-index-queries-0      ●  2/2          0 Running    3   58    10:0      100:0     30    n/a     58    n/a 10.233.88.26    wnode1 BU
loki-memcached-index-queries-1      ●  2/2          0 Running    2   59    10:0      100:0     20    n/a     59    n/a 10.233.126.92   wnode3 BU
loki-memcached-index-queries-2      ●  2/2          2 Running    1   56    10:0      100:0     10    n/a     56    n/a 10.233.73.86    wnode2 BU
loki-querier-866486df4d-2lhp7       ●  1/1          0 Running   11  439   100:0  1024:5120     11    n/a     42      8 10.233.126.18   wnode3 BU
loki-querier-866486df4d-lw94f       ●  1/1          4 Running    8  453   100:0  1024:5120      8    n/a     44      8 10.233.73.101   wnode2 BU
loki-querier-866486df4d-rmzw8       ●  1/1          0 Running   12  441   100:0  1024:5120     12    n/a     43      8 10.233.88.58    wnode1 BU
loki-query-frontend-7f89d8c6c7-5wn9j ● 1/1          0 Running    1  109   100:0   300:5120      1    n/a     36      2 10.233.126.219  wnode3 BU

<namespace> <pod>
```

ELASTICSEARCH VS LOKI



NEW STATELESS ELASTICSEARCH ARCHITECTURE



https://www.elastic.co/blog/stateless-your-new-state-of-find-with-elasticsearch

INFRA COMPARISON

ELASTICSEARCH

- CPU: 44
- Memory: 232 GB
- Main disks: 338 GB
- Storage disks: 25 TB

LOKI

- CPU: 7
- Memory: 14 GB
- Main disks: 105 GB
- S3 Storage: 5 TB

INFRA COMPARISON

High Load Armenia

ELASTICSEARCH

- CPU: 44
- Memory: 232 GB
- Main disks: 338 GB
- Storage disks: 25 TB

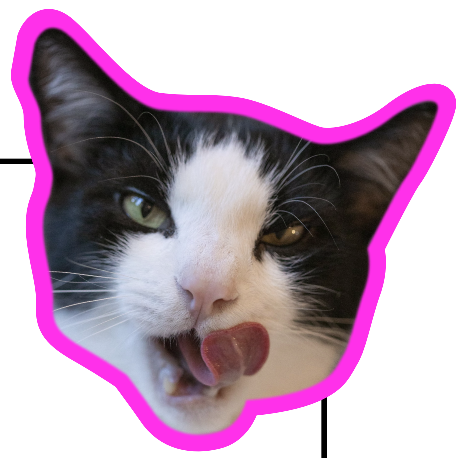
→

LOKI

- CPU: 7
- Memory: 14 GB
- Main disks: 105 GB
- S3 Storage: 5 TB

→

SAVINGS



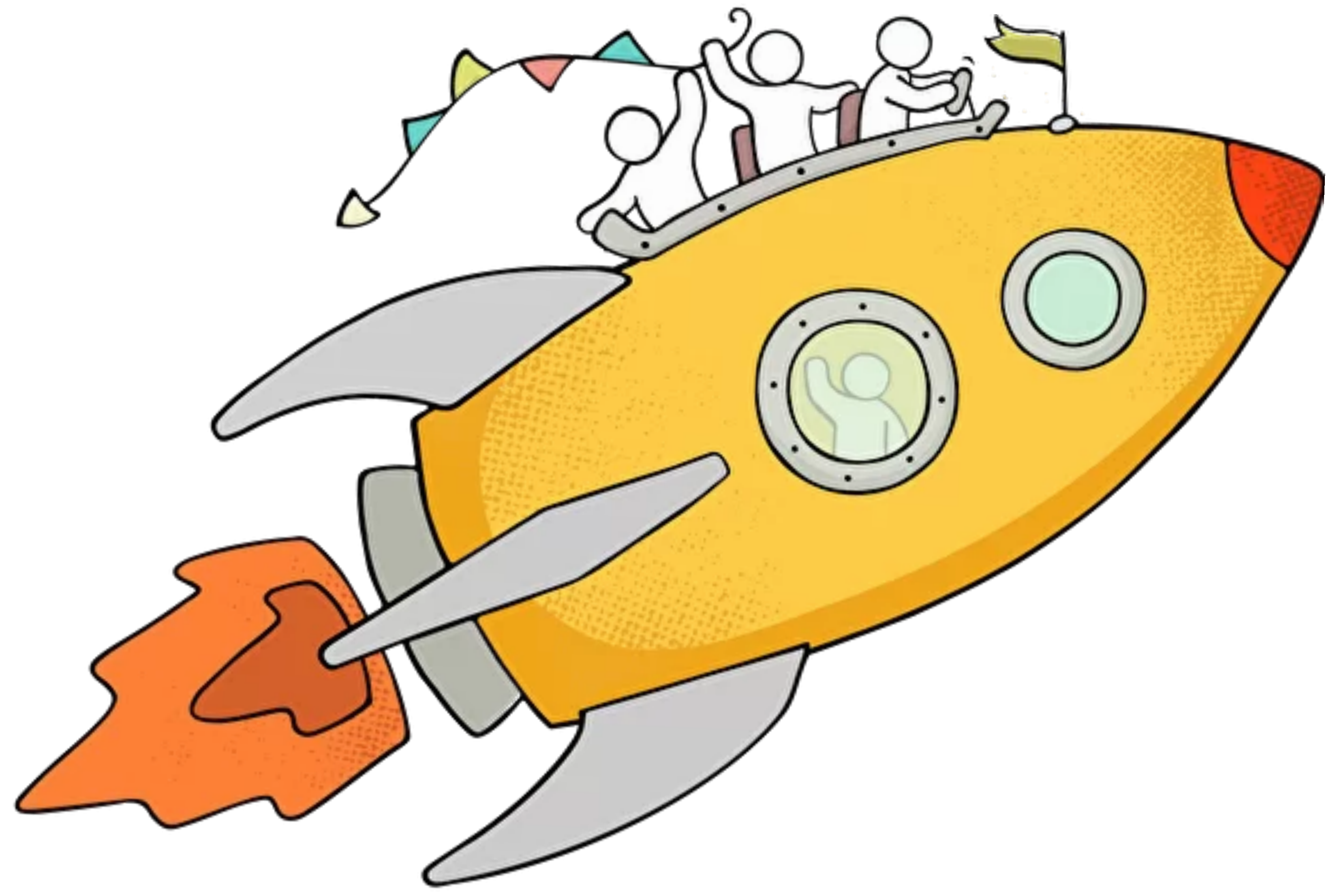
- 6x less CPU
- 16x less RAM
- 3x less disk
- 5x less main storage

→ RECAP

RESULTS

POSITIVE:

1. 4x logs infrastructure cost reduction
2. Simplier infrastructure maintanance
3. Much more stable installation than Elasticsearch
4. Logs transfer in adequate timespan
5. Easier to scale



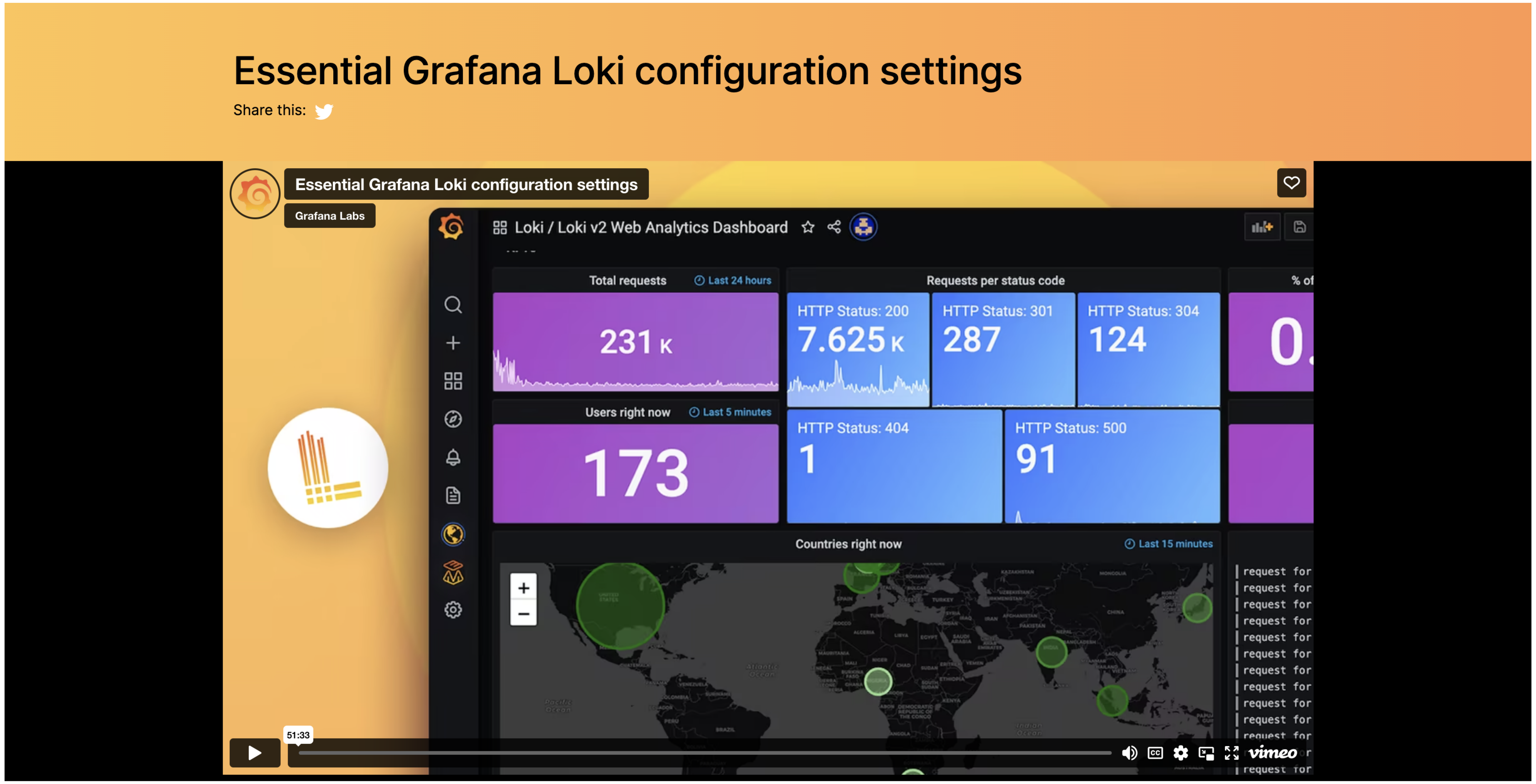
RESULTS

NOT SO POSITIVE, BUT OK:

1. Needed to use faster disks for S3
2. Grafana is not Kibana
3. No full-text search
4. No Machine Learning
5. Some queries in Loki are slower

LOKI CONFIGURATION → CHECKLIST (BONUS)

CONFIGURATION TIPS


Essential Grafana Loki configuration settings

Share this:

t.ly/vMvK

TECH TALKS - DECEMBER, 16

DYNAMIC
ENVIRONMENTS
WITH ARGOCD AND
CROSSPLANE

→ 11:00 - 11:20

[illegible]

MLOPS
IN ENTERPRISES
AND SMB

→ 15:30 - 15:50

IAAS

Leave your feedback!

You can rate the talk and give a feedback on what you've liked or what could be improved

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kts.studio

Co-organizer

Yandex